Protostellar Jets in Context

Program & Abstract Book

TOPICS

- The jet/wind-launching region
- The propagation, cooling, stability, and environmental impact of jets
- Laboratory experiments
- Similarities and differences between protostellar jets and their astrophysical siblings

Invited Speakers

F. Bacciotti	R. Bachiller	J. Bally	R. Bilyalov	S. Cabrit
M. Cai	T. P. Downes	J. Eislöffel	J. Ferreira	A. Frank
P. Hartigan	L. Hartmann	C. Johns-Krull	A. Koenigl	S. V. Lebedev
M. Livio	S. Massaglia	R. Matsumoto	B. Nisini	A. C. Raga
J. Richer	M. Romanova	J. H. Seiradakis	J. L. Sokoloski	J. Stone
E. Trussoni				

SOC chairs

K. Tsinganos T. P. Ray

JETSET Science Manager

S. Cabrit

LOC

K. Tsinganos N. Vlahakis M. Stute T. Matsakos P. Rammos

7 – 12 July 2008

Island of Rhodes, Greece

Scientific rationale

Protostellar Jets in Context is an international astrophysics conference organized at the initiative of the JETSET European Research and Training Network (RTN) (www.jetsets.org). It will take place from July 7-11, 2008 inclusive on the island of Rhodes, Greece. The main goal is to review the recent contributions of theoretical and computational modelling, high-resolution observations, and laboratory experiments to our understanding of jets and outflows from young stars. The connection with accretion disks and the similarities with outflow phenomena in other astrophysical contexts will also be explored. Members of the European RTN Molecular Universe and Constellation are also welcome to participate with their coordinators serving as members of the Scientific Organising Committee.

Topics to be discussed include:

• The jet/wind-launching region: Theories, observations, and numerical simulations that address the origin of atomic and molecular jets and winds in young stars, the physics of the star/disk interaction zone, the connectiion with accretion disks and the role of jets in removing angular momentum.

• The propagation, cooling, stability, and environmental impact of jets on scales from the stellar envelope to the parent cloud. Large-scale numerical simulations of collimated outflows including AMR codes and cluster/grid technologies. Observations and models of bipolar outflows, from the X-ray to the submm regime. The origin of knots in jets.

• Laboratory experiments that reproduce, in a scaled manner, key aspects of the dynamics of astrophysical jets relevant to their formation, collimation and interaction with the interstellar medium. Experimental benchmarks for HD and MHD codes and radiative transfer in jets.

• Similarities and differences between protostellar jets and their astrophysical siblings, for example coronal jets, outflows in planetary nebulae, pulsar jets, jets from symbiotic stars and compact binaries, as well as the collimated large-scale relativistic outflows associated with AGNs and GRBs.

The conference aims to bring together scientists working in these various fields to stimulate cross-disciplinary exchange. It will contain both invited and contributed talks, as well as poster sessions. Proceedings will be published by Springer-Verlag.

Organization

Protostellar Jets in Context is organized by the Section of Astrophysics, Astronomy and Mechanics, Department of Physics, University of Athens at the initiative of the JETSET European Research and Training Network (RTN).

SCIENTIFIC ORGANISING COMMITEE

Kanaris Tsinganos (Greece) (Co-Chair)
Tom Ray (Ireland) (Co-Chair)
John Bally (USA)
Sylvie Cabrit (France)
Suzan Edwards (USA)
Serguei Lebedev (UK)
Mario Livio (USA)
Mark McCaughrean (UK)
Silvano Massaglia (IT)
Alex Raga (Mexico)
Kazunari Shibata (Japan)
Frank Shu (USA)
Xander Tielens (NL)

LOCAL ORGANISING COMMITEE

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Titos Matsakos
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Acknowledgements

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• support from the Greek National Organization of Tourism EOT,
• support from the municipality of Rhodes.

Conference Program

Monday, July 7

08.00-13.00		Registration
09.00-09.15		Welcoming address, **K. Tsinganos**

Session 0 : Introductory reviews

09.15-09.55	**IR**	**M. Livio**: *Jets in Astrophysics*
09.55-10.35	**IR**	**J. Bally**: *Protostellar Jets*
10.35-11.20		Coffee Break

Session I : The star/jet/disk system

11.20-11.55	**IR**	**L. Hartmann**: *The star-jet-disk system and angular momentum transfer*
11.55-12.30	**IR**	**C. Johns-Krull**: *Hot inner winds from T Tauri stars*
12.30-12.50	**CT**	**A. Gomez de Castro**: *Hot gas in accretion disks and jets: a UV view of star formation*
12.50-13.10	**CT**	**S. G. Gregory**: *The magnetic fields of accreting T Tauri stars*
13.10-13.30	**CT**	**S. Mohanty**: *Magnetospheric Accretion with Multipole Stellar Fields: Theory and Observations*
13.30-16.30		Lunch break
16.30-17.05	**IR**	**J. Stone**: *Hydrodynamic and MHD Instabilities in Accretion Disks*
17.05-17.40	**IR**	**A. Koenigl**: *Theory of Wind-Driving Protostellar Disks*
17.40-18.20		Coffee Break and Poster Session
18.20-18.40	**CT**	**A. Mignone**: *Aspect ratio dependence in MRI shearing box simulations*
18.40-19.00	**CT**	**R. Lovelace**: *Advection of Magnetic Fields in Accretion Disks*
19.00-19.20	**CT**	**E. de Gouveia dal Pino**: *Magnetic reconnection processes in accretion disk systems*

IR = *Invited Review*, CT = *Contributed Talk*

Tuesday, July 8

Session II : Jet launching

09.00-09.35	**IR**	**J. Ferreira**: *Self-collimated jets: accretion disc and star-disc launching zones*
09.35-09.55	**CT**	**J. Staff**: *Large-scale 3D Simulations of Protostellar Jets: Constraining the Disk Wind Model*
09.55-10.15	**CT**	**G. Murphy**: *Viscous resistive magnetohydrodynamic disk simulations*
10.15-10.35	**CT**	**M. Stute**: *Extending analytical MHD jet formation models with a finite outer disk radius*
10.35-10.55	**CT**	**C. Fendt**: *MHD jets from different field configurations*
10.55-11.05	**CT**	**M. Cemeljic**: *Resistive MHD jet simulations*
11.05-11.30		Coffee Break
11.30-12.05	**IR**	**M. Cai**: *X-wind models*
12.05-12.40	**IR**	**M. Romanova**: *Disk-magnetosphere interaction and outflows*
12.40-13.00	**CT**	**C. Zanni**: *Simulating the launching of YSO jets*
13.00-13.20	**CT**	**C. Sauty**: *Can stellar jets brake efficiently T Tauri stars?*
13.20-13.40	**CT**	**F. Reale**: *Flaring activity in accretion flows of YSO*
13.40-16.30		Lunch break
16.30-17.05	**IR**	**R. Matsumoto**: *Similarities of the launching mechanism in protostellar/AGN jets*
17.05-17.40	**IR**	**S. Lebedev**: *Episodic Magnetic Tower Plasma Jets in a Laboratory Experiment*
17.40-18.00	**CT**	**N. Vlahakis**: *Jets in the MHD context*
18.00-18.20	**CT**	**N. Kylafis**: *Jets from stellar mass black holes*
18.20-19.30		Coffee Break and Poster Session

IR = *Invited Review*, CT = *Contributed Talk*

Wednesday, July 9

Session III : Observational constraints on jet launching

09.00-09.35	**IR**	**B. Nisini**: *Jets from embedded YSOs*
09.35-09.55	**CT**	**S. Antoniucci**: *Accretion luminosity and accretion-ejection rate connection in Class I sources*
09.55-10.30	**IR**	**F. Bacciotti**: *Resolved inner jets from T Tauri stars*
10.30-10.50	**CT**	**D. Coffey**: *Searching for jet rotation signatures in younger Class 0 and I jets - strengthening the observational support for magneto-centrifugal ejection*
10.50-11.30		Coffee Break and Poster Session
11.30-12.05	**IR**	**S. Cabrit**: *Observational challenges to ejection models in YSOs*
12.05-12.25	**CT**	**E. Whelan**: *T Tauri-like Outflow Activity in the Brown Dwarf Mass Regime*
12.25-12.45	**CT**	**A. Caratti o Garatti**: *Protostellar jets driven by intermediate- and high-mass protostars: an evolutionary scenario?*
12.45-13.20	**IR**	**S. Massaglia**: *The properties of AGN jets in comparison with Herbig-Haro jets*
		Free afternoon, excursions

IR = *Invited Review*, CT = *Contributed Talk*

Thursday, July 10

Session IV : Jet propagation, stability, interaction with the environment, X-ray emission

09.00-09.35	**IR**	**E. Trussoni**: *The KH-Instability and the propagation of stellar jets*
09.35-10.10	**IR**	**A. Raga**: *Jets from variable sources*
10.10-10.30	**CT**	**L. Podio**: *Stellar jets tomography in velocity space*
10.30-10.50	**CT**	**F. De Colle**: *Diagnostics of inhomogeneous stellar jets*
10.50-11.20		Coffee Break and Poster Session
11.20-11.55	**IR**	**P. Hartigan**: *Magnetic fields in Jets*
11.55-12.30	**IR**	**J. Eislöffel**: *Jet kinematics*
12.30-12.50	**CT**	**A. Ciardi**: *Bending the way of protostellar Jets*
12.50-13.10	**CT**	**J. Gracia**: *Synthetic jets from models to observations and back*
13.10-16.00		Lunch break
16.00-16.20	**CT**	**M. Güdel**: *X-Ray Emission from Young Stellar Jets*
16.20-16.40	**CT**	**R. Bonito**: *The complex morphology of the X-ray and optical emission from HH 154: the pulsed jet scenario*
16.40-17.00	**CT**	**C. Stehle**: *Radiative shocks: a combined analysis from experiments and simulations* (listed as Gonzalez et al.)
17.00-17.30		Coffee Break and Poster Session
17.30-18.05	**IR**	**J. Sokoloski**: *Jets from white dwarfs*
18.05-18.25	**CT**	**J. Kastner**: *X-ray Imaging Spectroscopy of Planetary Nebulae in the Era of Chandra and XMM-Newton: New Insight into Stellar Jets*
18.25-18.45	**CT**	**S. Orlando**: *3D modeling of the 2006 nova outburst of RS Ophiuchi: collimated outflows and jet-like ejections*
18.45-19.05	**IR**	**R. Bilyalov**: *"People" Programme: The Marie Curie Actions in FP7*
20.00		Conference Dinner

IR = *Invited Review*, CT = *Contributed Talk*

Friday, July 11

Session V : Molecular outflows and Turbulence injection by jets

09.00-09.35	**IR**	**R. Bachiller**: *Molecular outflows – observations*
09.35-10.10	**IR**	**T. Downes**: *Molecular outflows – modelling*
10.10-10.30	**CT**	**J. Schmid-Burgk**: *Rotation observed in the molecular outflow OriS6 and its bullets*
10.30-10.50	**CT**	**M. Machida**: *Protostellar Jet and Outflow in the Collapsing Cloud Core*
10.50-11.40		Coffee Break
11.40-12.15	**IR**	**A. Frank**: *Jets and turbulence*
12.15-12.35	**CT**	**R. Banerjee**: *Can protostellar outflows drive turbulence in molecular clouds?*
12.35-13.10	**IR**	**J. Richer**: *Prospects for Outflow and Jet Science with ALMA*
13.10-16.00		Lunch break
16.00-16.20	**CT**	**T. Lery**: *The International Year of Astronomy 2009. An opportunity for European Astrophysicists*
16.20-17.00		Summary of Posters
17.00-17.30		Coffee Break
17.30-18.00		Summary and Concluding Remarks, **T. Ray**
18.00-18.40	**IR**	**J. Seiradakis**: *The Antikythera Mechanism: Astronomy and Technology in ancient Greece*

IR = *Invited Review*, CT = *Contributed Talk*

Saturday, July 12

Session VI: Jetset early stage researcher presentations
Open to all

09.00-09.20	**CT**	**T. Matsakos**: *Two-component jet simulations: Mixing analytical disk and stellar outflow solutions*
09.20-09.40	**CT**	**O. Tesileanu**: *MHD Simulations of Radiative YSO Jets*
09.40-10.00	**CT**	**J. O'Sullivan**: *Molecular Cooling Effects in Large scale Simulations of Herbig Haro Objects*
10.00-10.20	**CT**	**D. Panoglou**: *The survival of molecules in MHD disk winds*
10.20-10.40	**CT**	**M. Bocchi**: *Kelvin-Helmholtz instability in magnetized jets*
10.40-11.20		Coffee Break and Poster Session
11.20-11.40	**CT**	**O. Dionatos**: *Jets from Class 0 protostars: A Spitzer - IRS view*
11.40-12.00	**CT**	**V. Agra-Amboage**: *0.15" study of the atomic and molecular jets in DG Tau*
12.00-12.20	**CT**	**R. Garcia Lopez**: *IR diagnostic of embedded jets: velocity resolved observations of the HH34 and HH46-47 jets*
12.20-12.40	**CT**	**S. Rajabi**: *Line formation in outflows from young stars*
12.40-13.00	**CT**	**F. Suzuki-Vidal**: *Interaction of a Supersonic Radiatively Cooled Plasma Jet with a Background Ambient*
13.00-13.20	**CT**	**A. Marocchino**: *Numerical Studies for Episodic Magnetically Driven Plasma Jets*
		Lunch break

Jetset Board and Science meeting (restricted), Departures

IR = *Invited Review*, CT = *Contributed Talk*

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Part I

Invited Talks

Resolved inner jets from T Tauri stars

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Summary. The jet mechanism appears to be very robust in Nature, as jets are observed in association with a large variety of astronomical objects, spanning over ten orders of magnitude in mass. Understanding how jets are generated is therefore of wide interest to the astrophysical community, and many models have been developed to explain the ejection of mass around an accreting object.

A viable way to test observationally the proposed theories is to investigate the inner regions of jets emanated by nearby young stars in the T Tauri phase. At this evolutionary stage the central star is not embedded anymore in the formation material, and instruments working at sub-arcsecond angular resolution, like those on-board the Hubble Space Telescope, or mounted at ground-based telescopes equipped with Adaptive Optics, allow us to probe the flows in their acceleration and collimation region. The application to these data of new methodologies of analysis and spectral diagnostics have brought an impressive wealth of morphological, kinematical and physical information on the region within the first 200 AU from the star, providing the most stringent constraints to date for the various models.

Here some of the most interesting findings in this area are reviewed. These include determinations of the jet widths and poloidal velocity fields, estimates of the gas excitation parameters, estimates of the mass and momentum fluxes close to the source and finally, a presentation of the indications for jet rotation, i.e. that jets may indeed transport the excess angular momentum away from the system.

Molecular outflows – observations

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Summary. The history of the mass loss episodes from a young stellar object remains written in the surrounding molecular medium in the form of perturbations created by the propagation of the jets and winds. CO observations of the swept-up material is an essential tool to estimate crucial characteristics of mass loss phenomena. We first review current estimates of bipolar outflow parameters, obtained from CO observations, by paying attention to observational limitations and biases.

We then stress that the propagation of a supersonic protostellar outflow through its surrounding medium happens via shock waves. The rapid heating and compression of the gas triggers different microscopic processes such as molecular dissociation, endothermic reactions, ice sublimation, and dust grain disruption , which do not operate in the unperturbed gas, generating peculiar chemical anomalies. We review, from an observational point of view, the influence of shocks on chemistry emphasizing recent observations of outflows from Class 0 sources with favorable orientation in the sky (i.e. high inclination with respect to the line of sight). With less confusion than that found around massive outflows, the shocked regions of low-mass high-collimation outflows, often adopt the form of well-defined bows which are well separated spatially with respect to the quiescent gas. The behaviour of key molecules such as H_2O, SiO, FeO, CH_3OH, H_2CO, HCO+, CN, Sulfur-bearing molecules, etc, is summarized. We also present recent results of a comprehensive chemical survey aimed to study the evolution of young protostellar outflows (Ph. D. work of J. Santiago). It appears that the peculiarities of the chemical behaviour together with other structural parameters such as the presence of extremely high velocity features (molecular bullets), the collimation factors, and the mechanical power efficiencies, can be used to produce a rough classification of the observed outflows and to suggest a time evolutionary sequence.

We finally provide some prospects with the future ALMA observations. The superb sub-arcsecond angular resolution together with the high sensitivity in a variety of molecular lines will be particularly useful to study the outflow launching regions, the details of the entrainment mechanisms, and the abundance of very rare molecules which are expected to be created by the shocks.

Protostellar Jets

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Summary. Jets and outflows from young stars are ubiquitous and one of the most spectacular manifestations of the birth of a young star. Because they are abundant, and can be investigated in a large variety of line and continuum tracers from radio to X-ray wavelengths, they are excellent laboratories for the study of accretion-driven jet phenomena in all astrophysical contexts. I will review jet and wind interactions with themselves and their environment to produce shocks, molecular outflows, and turbulence in their host clouds. Outflows contribute to feedback and self-regulation in star formation and the disruption of their host clouds. Jets are time variable in every parameter, giving rise to a rich variety of observed structure and kinematics. Internal shocks provide fossil records of the mass-loss and accretion histories. Outflow structure and symmetries can indicate dynamical processes such as deflection by side-winds or radiation pressure, precession of the source disk, or interactions with sibling stars. I will show examples of precessing, pulsed, and bent jets, Herbig-Haro objects, molecular outflows, externally irradiated systems, and interacting multiple flows in clusters. Finally, I will comment on how studies of protostellar outflows may contribute to our understanding of jets in other contexts such as AGN, post-main sequence objects, and other sources of collimated flow.

"People" Programme: The Marie Curie Actions in FP7

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Summary. Europe needs research and research needs Europe. The EUs Marie Curie Actions help to fund all kinds of training and mobility opportunities for researchers throughout their careers. That is why the 'Marie Curie Actions' have long been one of the most popular and appreciated features of the Community Framework Programmes for Research and Technological Development. They have developed significantly in orientation over time, from a pure mobility fellowships programme to a programme dedicated to stimulating researchers' career development. The 'Marie Curie Actions' have been particularly successful in responding to the needs of Europe's scientific community in terms of training, mobility and career development. This has been demonstrated by a demand in terms of highly ranked applications that in most actions extensively surpassed the available financial support. In the Seventh Framework Programme, the 'Marie Curie Actions' have been regrouped and reinforced in the 'People' Specific Programme. Entirely dedicated to human resources in research, this Specific Programme has a significant overall budget of more than €4,7 billion over a seven year period until 2013, which represents a 50% average annual increase over FP6.

The detailed overview of all Marie Curie actions is given. The 'People' Specific Programme will be implemented through actions under five headings:

- Initial training of researchers to improve mostly young researchers career perspectives in both public and private sectors, by broadening their scientific and generic skills, including those related to technology transfer and entrepreneurship.
- Life-long training and career development to support experienced researchers in complementing or acquiring new skills and competencies or in enhancing inter/multidisciplinarity and/or intersectoral mobility, in resuming a research career after a break and in (re)integrating into a longer term research position in Europe after a trans-national mobility experience.
- Industry-academia pathways and partnerships to stimulate intersectoral mobility and increase knowledge sharing through joint research partnerships in longer term co-operation programmes between organisations from academia and industry, in particular SMEs and including traditional manufacturing industries.
- International dimension, to contribute to the life-long training and career development of EU-researchers, to attract research talent from outside Europe and to foster mutually beneficial research collaboration with research actors from outside Europe.

- Specific actions to support removing obstacles to mobility and enhancing the career perspectives of researchers in Europe.

The 'People' Specific Programme acknowledges that one of the main competitive edges in science and technology is the quantity and quality of its human resources. To support the further development and consolidation of the European Research Area, this Specific Programme's overall strategic objective is to make Europe more attractive for the best researchers.

Observational challenges to ejection models in YSOs

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Summary. Several origins have been proposed for the collimated jets observed in young stars: (1) a thermally-driven, accretion-powered stellar wind, (2) an episodic flow fed by reconnexions in the stellar magnetosphere, (3) a centrifugal disk wind, driven either from the inner disk edge or from a wide range in radii. While all of these processes may in fact co-exist, one of them probably dominates the jet mass-flux.

A wealth of data has now become available on observational properties of resolved jets (jet widths, poloidal speeds and transverse structure, rotation speeds, ejection/accretion ratio, iron depletion, molecular content...). They are used to reconsider critically the predictions of theoretical models, and their main successes and shortcomings at reproducing the characteristics of stellar jets. The importance of building "synthetic observations" for meaningful comparisons of models with observations will also be highlighted.

X-wind models

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Summary. Based on the principle of magneto-centrifugal acceleration, the interaction of an electrically conducting accretion disk with the magnetosphere of a young star will naturally give rise to X-winds and funnel flows. A distinguishing feature of the X-wind model is the trapped flux in a small region at the inner edge of the disk, where both the X-wind and the funnel flow originate. This magnetic configuration leads to predictions such as disk locking, wide angle winds, hollow jets, etc. In this talk, we will review the theoretical developments of the X-wind model and how some of its predictions can be tested by observation.

The driving mechanisms for Molecular outflows

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Summary. In this talk we review the various models for molecular outflows, focussing in particular on jet- and wind-driven models. Currently it seems that both of these models can be used successfully to model specific outflows, although it is not clear yet whether either could be successful in modelling all outflows. We describe the strengths and weaknesses of these possible driving mechanisms and discuss what paths might be taken in exploring this problem further in the future.

Jet kinematics

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Summary. No abstract has been provided.

Self-collimated jets: accretion disc and star-disc launching zones

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Summary. In this review, I will first address the physical conditions that must prevail within near Keplerian accretion discs in order to steadily launch cold self-collimated jets. It will be shown that, under reasonable assumptions concerning the turbulent transport coefficients, the large scale vertical magnetic field must be close to equipartition with the thermal pressure. These conditions raise the question of the magnetic field distribution and its evolution in time within the disc. It will then be shown that jet emitting discs have properties (both dynamical and thermal) quite distinct from usual standard discs.

In a second part, I will present some results on two scenarios linking the stellar magnetosphere to the disc and also giving rise to ejection. The first one exhibits a Y-type magnetic neutral line above the disc and triggers "X-winds" when the disc launching zone is limited radially (Shu et al 1994). The second exhibits a X-type magnetic neutral line within the disc and has been invoked to efficiently brake down a protostar through "reconnection X-winds" (Ferreira et al 2000).

Jets and turbulence

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Summary. The link between turbulence in star formatting environments and protostellar jets remains controversial. To explore issues of turbulence and fossil cavities driven by young stellar outflows this talk first presents a series of numerical simulations tracking the evolution of transient protostellar jets driven into a turbulent medium. Our simulations show both the effect of turbulence on outflow structures and, conversely, the effect of outflows on the ambient turbulence. We demonstrate how turbulence will lead to strong modifications in jet morphology. More importantly, we demonstrate that individual transient outflows have the capacity to re-energize decaying turbulence. We then explore direct driving of turbulence in molecular clouds by multiple protostellar outflows. Using 3-D numerical simulations we focus on the hydrodynamics of multiple outflows interacting within a parsec scale volume and investigate the extent to which overlapping transient outflows injecting directed energy and momentum can be converted into random turbulent motions. We show that turbulence can readily be sustained by these interactions and show that it is possible to broadly characterize an effective driving scale of the outflows. We compare the velocity spectrum obtained in our studies to that of isotropically forced hydrodynamic turbulence finding that in outflow driven turbulence a power law is indeed achieved. However we find a steeper spectrum is obtained in outflow driven turbulence models than in isotropically forced simulations. We discuss possible physical mechanisms responsible for these results as well and their implications for turbulence in molecular clouds where outflows will act in concert with other processes such as gravitational collapse.

Magnetic fields in Jets

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Summary. No abstract has been provided.

The star-jet-disk system and angular momentum transfer

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Summary. The region of interaction between the stellar magnetosphere and the circumstellar disk is enormously complicated and time-dependent. In addition, it is puzzling that accreting stars - stars with continuing angular momentum addition - also seem typically to be slow rotators, as if angular momentum were being extracted into the disk or wind. I will review some of the main issues involved and offer a speculation as to how angular momentum loss really occurs during accretion.

Hot inner winds from T Tauri stars

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Summary. P-Cygni components in the H-alpha line have been known in Classical T Tauri Stars for several decades. However, the nature of this mass loss including the driving mechanism and its thermal structure are still not well known. Recently, renewed effort has been expended to constrain the thermal structure of this inner wind, and there is not evidence that the temperature in this flow reaches a few tens of thousands of degrees K. There is considerable debate over just how hot these winds get. I will review the observational evidence on the inner winds of T Tauri stars, focussing on the evidence which constrains the thermal structure of the flow.

Theory of Wind-Driving Protostellar Disks

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Summary. The most widely accepted explanation of protostellar jets is that they tap the rotational kinetic energy of the associated disk or protostar and that, even if thermal pressure plays a role in their initial acceleration, they are predominantly driven centrifugally by the stress of a large-scale, ordered magnetic field that threads the source. Although the questions of whether the outflow is launched only in the immediate vicinity of the protostar and whether the magnetic field originates in the disk or the protostar are still not settled, it is clear that the observed outflows are intimately tied to the accretion process, and in essentially all models the bulk of the outflowing mass comes from the disk. Furthermore, it has been argued that most of the mass and momentum ejected over the lifetime of a Sun-like protostar originates in the vigorous accretion and outflow episodes known as FU Orionis outbursts, and in this case there is direct evidence from observations of the prototype object that the outflow emanates from a circumstellar disk and that a strong magnetic field threads the disk.

Protostellar disks evidently form in the gravitational collapse of molecular cloud cores. There is strong observational evidence in a number of such cores that they are threaded by a large-scale, dynamically important, interstellar magnetic field. This field will be advected inward when the core collapses and, even though magnetic diffusivity will prevent most of the original flux from reaching the center, it can naturally account for the "open" magnetic field lines needed to drive a disk wind. (A disk dynamo may potentially also give rise to the requisite field.) Centrifugally driven winds are an efficient means of transporting angular momentum vertically out through the disk surfaces. A complementary process of vertical transport along an open magnetic field, which can also be important in the natal cloud core, is the launching of torsional hydromagnetic waves into the ambient medium (magnetic braking). In addition, the large-scale field can serve as a seed for the development of hydromagnetic turbulence induced by the magnetorotational instability, which would remove angular momentum along the disk plane. In principle, all three magnetic transport mechanisms could operate in a protostellar disk, and some might even coexist at the same radial location.

In this contribution I will present detailed models of the formation and structure of magnetic wind-driving protostellar disks. I will discuss the distinct physical properties of such disks and how they depend on the degree of field–matter coupling

in the weakly ionized interior regions. Recent work on global disk/wind models and on processes involving dust grains will also be described.

Episodic Magnetic Tower Plasma Jets in a Laboratory Experiment

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Summary. We will present experimental results on formation of supersonic magnetically driven plasma jets with dimensionless parameters similar to those in protostellar jets. The jets are driven by the pressure of the toroidal magnetic field and the plasma beta in these jets is of the order of unity [1,2]. The experimental configuration allows generation of several episodes of the magnetic tower jet eruptions. The subsequent magnetic bubbles have higher propagation velocities and are catching up the previously ejected, producing shocks. These experiments suggest that periodic formation of magnetic tower jets in the astrophysical situations could be responsible for some of the variability of the astrophysical jets. The experiments are scalable to astrophysical flows in that critical dimensionless numbers such as the plasma collisionality, the plasma beta and the magnetic Reynolds number are all in the astrophysically appropriate ranges. The experimental results will be compared with computer simulations performed with laboratory plasma codes and with astrophysical codes.

This research was supported in part by the European Communitys Marie Curie Actions Human Resource and Mobility within the JETSET network under contract MRTN-CT-2004 005592 and the Stewardship Sciences Academic Alliances program of the NNSA under DOE Cooperative Agreement DE-FC03-02NA00057.

[1] S.V. Lebedev et al., Mon. Not. R. Astron. Soc., 361 97 (2005)
[2] A. Ciardi et al., Physics of Plasmas, 14, 056501 (2007)

Jets in Astrophysics

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Summary. I will show that the assumption that the acceleration and collimation mechanisms of jets are the SAME in all classes of astrophysical objects which are observed to produce jets, can lead to interesting constraints on jet formation.

Jets have now been observed in: AGNs, young stellar objects, x-ray binaries, black hole x-ray transients, symbiotic systems, supersoft x-ray sources, pulsars, and possibly planetary nebulae and recurrent novae. I will attempt to identify the necessary ingredients for the production of powerful jets, and will suggest critical observations that can test the ideas presented in this talk.

The properties of AGN jets in comparison with Herbig-Haro jets

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Summary. The principal questions concerning the nature of AGN jets, i.e. their compositions, velocity, density and distribution of the magnetic field are still open after many decades since their discovery. This is because of the impossibility of observations able to directly constrain these parameters, due to the non-thermal origin of the emitted radiation. I will review the basic properties of AGN jets and discuss how it can be possible to constrain some parameters by indirect means and what one can gain from the comparison with the phenomenology of Herbig-Haro jets.

Similarities of the launching mechanism in protostellar/AGN jets

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Summary. We present the results of global 2D and 3D resistive magnetohydrodynamic (MHD) simulations of jet formation from a gas disk rotating around a central object. In a disk-star system, differential rotation twists magnetic loops connecting a star and its disk. As magnetic twist accumulates, the magnetic loops inflate and form current sheets inside the loops. Magnetic reconnection taking place in the current sheet can be the origin of X-ray flares observed in protostars.

Numerical simulations using larger computing area revealed that the expanding magnetic loops form a magnetic tower. Intermittent magnetic reconnection taking place near the footpoints of the tower injects plasmoids into the tower. The collimated outflow of the hot plasma can be the origin of optical jets. Less collimated outflow of cool gas emanates from the disk along the large-scale magnetic fields formed by the magnetic loop expansion.

We also show that even when the central object is a black hole, and large-scale poloidal magnetic fields do not exist at the initial state, poloidal magnetic fields are generated due to the buoyant rise of magnetic loops from the accretion disk. These magnetic loops are twisted, elongated, and form magnetic towers. Thus, the stellar surface is not essential for producing magnetically driven outflows. Core-jet and outer wind structure is common both in AGNs and in protostars.

Jets from embedded YSOs

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Summary. In this talk I will review recent results obtained by means of near-IR and sub-mm observations on the physical and kinematical properties of young embedded stars (the so called class 0 and I objects). I will then discuss the comparison with the properties of the older and optically visible T Tauri stars, addressing similarity and differences linked to the evolution.

Jets from variable sources

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Summary. The theory of variable jets was deviced for astrophysical jets, and the resulting models have been successful at reproducing some of the structures observed in a number of HH jets. Analytic models (with different degrees of approximation) have been developed for jets with a variable ejection velocity, with a variable ejection direction, and with a general (direction+modulus) ejection variability. Axisymmetric and 3D numerical simulations have also been carried out, covering a moderately wide range of possible variabilities. A summary of the past work on variable jets will be presented, as well as a set of new models illustrating the possible flow configurations that can be obtained. Finally, examples of the results that are obtained when attempting to model specific HH jets will be discussed.

Prospects for Outflow and Jet Science with ALMA

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Summary. Developing a detailed understanding of molecular outflows and jets from YSOs remains a key objective of research into star formation. Much recent progress has come from new high-resolution spectroscopic images of outflows using submillimetre and millimetre interferometry. ALMA, the Atacama Large Millimetre/submillimetre Array, will be the first instrument capable of resolving outflows at very high angular resolution, down to 0.01 arcsec, and will allow for the first time detailed images of outflow generation close to the driving protostar, and very detailed images of gas acceleration and propagation. For the nearest sources, we will be able to image flows on scales close to 1 AU, which will give an unprecedented insight into the driving mechanism of outflows, and the link the protostellar accretion disks. In this talk I will present the current status of ALMA, review its capabilities of relevance to outflow and disk studies, and discuss some of the exciting opportunities for outflow science with ALMA.

Disk-magnetosphere interaction and outflows

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Summary. Interaction of a rotating magnetized star with an accretion disk leads to disruption of the disk and to accretion of matter to the star and in many cases to outflows. Three-dimensional simulations have shown that matter may accrete to a star either through ordered funnel streams, which form ordered hot spots at the surface of the star, or through stochastically forming tongues, which penetrate through magnetosphere due to the Rayleigh-Taylor instability and form spots at random locations. Thus magnetized stars may show different properties depending on regime of accretion. If the viscosity is larger than diffusivity, then magnetic field lines are bunched into an X-type configuration and part of the accreting matter may flow from the disk-magnetosphere boundary to conical winds due to magneto-centrifugal forces. Young protostars may be in the propeller regime where the magnetosphere rotates faster than the inner edge of the disk. In this regime two-component structure of the outflows has been observed: (1) most of the disk matter may be re-directed by the fast rotating magnetosphere to matter-dominated conical winds; (2) most of the energy and angular momentum may flow to the axial Poynting flux jets, where only small amount of matter is accelerated up to very high speed. Young stars may lose significant part of their angular momentum in the propeller stage.

The Antikythera Mechanism: Astronomy and Technology in ancient Greece

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Summary. The Antikythera Mechanism was found by chance, in a shipwreck, close to the small Greek island of Antikythera (between Crete and Peloponnese) in April 1900, by sponge divers. The shipwreck was dated between 86 and 67 B.C. (coins from Pergamon). The Mechanism has been dated, by epigraphologists, around the second half of the 2nd century B.C. (100 150 B.C.). About this time the great Greek astronomer Hipparchos (190 120 B.C.) lived in Rhodes.

It was a portable (laptop-size), geared artifact which calculated and displayed, with high precision, the movement of the Sun and the Moon on the sky, the phase of the Moon for a given epoch and could predict eclipses. It had one dial on the front and two on the back. Its 30 precisely cut gears were driven by a manifold, with which the user could set a pointer to any particular epoch (at the front dial). While doing so, several pointers were synchronously driven by the gears, to show the above mentioned celestial phenomena on three accurately marked annuli. It contained an extensive users manual. The exact function of the gears has finally been decoded and a large portion of the manual has been read after 2000 years by a major new investigation, using state of the art equipment.

No complicated geared instruments are known before the Antikythera Mechanism and for several centuries after. Therefore, this astronomical device, which stands out as an extraordinary proof of high tech in ancient times, imposes a compelling need to re-write the books of the history and evolution of early Technology.

Jets from white dwarfs

J. L. Sokoloski

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Summary. Accreting white dwarfs (WDs) have recently been recognized to be a new class of jet-producing objects. Of the three main types of accreting WDs – cataclysmic variables (CVs), supersoft X-ray binaries, and symbiotic stars – all have now shown evidence for jets. Moreover, symbiotic-star jets are often large enough to be spatially resolved. Jets from the WDs in symbiotic stars share some characteristics with the non-relativistic outflows from both protostellar objects and X-ray binaries. They thus provide a bridge between relativistic and non-relativistic jets, and play a special role in the search for a jet model that might apply to all types of accreting systems. I will review what is known about WD jets, with a focus on recent observations. These observations include radio images of nova jets that terminate in synchrotron lobes, the first evidence for radio jets from CVs, and observational support for a disk-jet connection in WDs.

Hydrodynamic and MHD Instabilities in Accretion Disks

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Summary. Understanding the internal dynamics of accretion disks is important for understanding the production of jets and winds, since ultimately it is the disk that is the source of such outflows, either via direct launching, or via dynamical interaction with the central star. Much has been learned about the physical processes that drive angular momentum transport in astrophysical accretion disks through hydrodynamical and magnetohydrodynamical (MHD) simulations. Local simulations of a small patch of a fully ionized disk reveal that MHD turbulence driven by a local, linear instability (the magnetorotational instability, or MRI) is an important source of transport. Studies of vertically stratified disks show that this turbulence drives a dynamo which, in combination with buoyancy, results in a strongly magnetized corona above the disk. Recent work has concentrated on global models in which the structure and evolution of the entire disk is computed from first principles. In protostellar disks, the equatorial regions are only very weakly ionized, and the ideal MHD limit does not apply. In these regions the MRI can be suppressed by Ohmic resistivity, and in the ambipolar diffusion and Hall MHD regimes the nonlinear saturation of the MRI is strongly affected by non-ideal MHD effects. It is likely that a thin surface layer of the disk will be sufficiently ionized by x-rays from the central protostar so that the disk has a layered structure, with a laminar, quiescent dead zone in the center, sandwiched between turbulent active layers. However, there is much uncertainty about the effect of dust on the ionization fraction in the active layers, and therefore the degree to which they are coupled to the magnetic field, primarily due to the possibility of grain growth and settling. Finally, a number of new studies of the effect of vortices on angular momentum transport in hydrodynamic disks have revealed that only large-scale vortices are long-lived, and that transport via local nonlinear hydrodynamic instability is most likely negligible. I will review this progress in understanding the internal dynamics of disks, and comment on the implications for the production of winds and jets.

The KH-instability and the propagation of stellar jets

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Summary. Since the discovery of jets in radio galaxies in early '70s, the Kelvin-Helmoltz Instability (KHI) has been envisaged as one of the fundamental processes that rules the dynamics of collimated outflows from astrophysical bodies. It turns out in particular from studies in these last 15 - 20 years, that the KHI is likely to be strictly connected with the phenomenology observed in jets in Young Stellar Objects. The main physical properties of KHI in linear and non linear regime will be outlined considering physical conditions typical in astrophysical contexts (2-D and 3-D geometry, magnetic fields, radiative losses, etc.). Then it will be discussed how the onset of the KHI can affect the evolution of stellar jets leading to the various morphological and radiative features observed in these objects.

Part II

Oral Presentations

0.15” study of the atomic and molecular jets in DG Tau

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Summary. The physical mechanism by which mass is ejected from accreting systems and collimated into jets is a fundamental open problem in star formation. Magnetohydrodynamic accretion-driven wind models best explain the efficient collimation and the large mass ejection efficiencies observed. However, the exact origin of the outflow is not yet determined. The aim of the present study is to find observational constrains on the jet launching region using high angular resolution observations of the inner 150 AU of T Tauri jets.

I will present the results of a spectro-imaging study of the DG Tau microjet in [FeII] and H2 lines emission allowing for the first time to compare the atomic and the molecular jet properties. Our observations were taken using the Integral Field Spectrograph SINFONI at VLT, combined with adaptive optics, yielding a spectral resolution of 100 km/s and spatial resolution of 0.15” = 20 AU. These observations allow us to carry out a detailed comparison of the jet morphology, kinematics, and excitations conditions in both the atomic and the molecular components. The results are compared to MHD disk wind models and bring new insight into the launch region of collimated jets in young stars.

Can protostellar outflows drive turbulence in molecular clouds?

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Summary. The interstellar medium (ISM) and star orming molecular clouds are permeated by turbulent, supersonic gas motions. But so far we can only speculate on the origin of this supersonic turbulence. A difficulty of supersonic turbulence is that it decays quickly and has to be continuously driven to be maintained. The energy input can in principle be provided by sources within the molecular cloud (e.g., radiation from massive stars, outflows) or from outside (e.g., supernovae, galactic spiral arms). Maintaining the turbulence on small scales from within the MCs is an attractive idea as is could lead to the self-regulation of star formation. In this talk, I will present our recent numerical study on jet driven turbulence and show that collimated supersonic jets do not excite supersonic motions far from the vicinity of the jet. Instead, supersonic fluctuations are damped quickly and do not spread into the parent cloud, whereas subsonic,non-compressional modes occupy most of the excited volume. Nevertheless, jets are able to leave strong imprints in their cloud structure and can disrupt dense clumps. Our results question the ability of collimated jets to sustain supersonic turbulence in molecular clouds.

Kelvin Helmholtz instability in magnetized jets

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Summary. Although several observations, models and theories have been made, very important aspects of the astrophysical jets are still puzzling the scientists. The main ingredients for the jet launching mechanism are thought to be accretion disks and magnetic fields, but the details of the process as well as the outflow characteristics, are not completely understood.

The presence of magnetic fields with helical topology, often invoked to explain the confinement of the jets, can cause the growth of current driven instabilities, known to be very dangerous for the coherence of the flow. The observations of long collimated jets are themselves a puzzle, because cylindrical beams are affected by the Kelvin Helmholtz instability, that can rapidly disrupt the flow.

As part of my Ph.D. thesis I address this problem performing numerical magneto-hydro-dynamic (MHD) simulations of young stellar object (YSO) jets using the pluto code (Mignone et al. 2007), and I explore the interesting possibility that the knots and helical features observed in astrophysical jets are caused by the growth of instabilities in the beam.

I will present as a first result a temporal study (periodic boundary conditions) on the Kelvin Helmholtz (KH) instability in different physical setups, relevant to the jet shear layer with the ambient medium, with special emphasis on the topology of the magnetic field and the explanation of the formation of magnetic islands due to reconnection events (see for examples of similar setups Keppens et al. 1999 and Jeong et al. 2000). Although frequently the jets are modeled numerically in cylindrical symmetry, this particular choice cannot take into account the non-axisymmetric modes of the instabilities.

As a second result I will present 2D "slab" as well as full 3D simulations to better understand the global effect of the KH instabilities on the jet survival and morphology. With the aid of large scale spatial simulations (inflow-outflow boundary conditions) I will show that convective effects are essential for the global picture of the jets also in supersonic regimes (Viallet et al. 2007 observed this effect in trans-sonic regimes only). In the end, I will talk about the prospects and additional work needed to include helical magnetic fields and rotation of the jet in the simulations. I will show the first attempts to reach higher mach numbers to compute virtual observations from the simulations using the Jetset pipeline and compare them with real observations.

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Keppens R., Toth G., Westermann R.H.J., Goedbloed J.P., 1999, J. Plasma Physics, vol.61
Mignone A., Bodo G., Massaglia S., Matsakos T.,Tesileanu O., Zanni C., Ferrari A., 2007, ApJ Supplement, 170, 228
Viallet M., Baty H., 2007, A & A, 473, 1-9

The complex morphology of the X-ray and optical emission from HH 154: the pulsed jet scenario

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Summary. HH 154 is one of the nearest protostellar jet from which X-ray emission has been detected with both XMM-Newton and Chandra. The X-ray source associated with this object shows a complex morphology consisting of two components: a bright point-like emission, localized at the base of the jet, which shows no detectable proper motion (at least over the four years of time base), and an extended tail, probably a blob moving away from the protostar from which the jet originates, with a proper motion of about 500 km/s.

On the other hand, the 2005 HST observations of the same jet, point out the possibility of the formation of a new shock front at the base of the jet. There is placed one of the brightest optical knot from which the highest velocities have been measured in the previous epochs. We therefore suggest to identify this knot with an internal working surface and to relate the position of this new optical shock with that of the X-ray source.

In order to investigate the physical mechanisms explaining the X-ray emission detected in HH jets, we developed a model of a continuous jet traveling through an homogeneous ambient medium. This simple model describes the basic physics of the mechanism leading to X-ray emission consistent with the observations, however, it fails to explain 1) the extended morphology of the X-ray source which exhibits detectable proper motion and 2) the stationary component located at the base of the jet.

As a follow up of our model of a continuous jet ramming into the ambient medium, we developed the model of a protostellar jet ejected with variable initial velocity. The case of a pulsed jet is a more realistic scenario, in fact it reproduces the knotty morphology observed within the protostellar jets and it is consistent with an X-ray source mainly localized at the base of the jet, as detected in HH 154.

Protostellar jets driven by intermediate- and high-mass protostars: an evolutionary scenario?

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Summary. Protostellar jets from intermediate- and high-mass protostars provide an excellent opportunity to understand the mechanisms responsible for intermediate- and high-mass star formation. A crucial question is if they are scaled-up versions of their low-mass counterparts.

We present a detailed study of the IRAS 20126+4104 molecular jet, driven by a 10^4 $L_\odot$ protostar. The kinematical and physical properties of the jet have been obtained by means of NIR narrow-band imaging, high resolution and low resolution IR spectroscopy. We then compare our findings with those of other high- and low-mass protostellar jets available in literature, proposing an evolutionary scenario from low- to high-mass jets.

Resistive MHD jet simulations

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Summary. We perform axisymmetric resistive MHD simulations for a generalised solution of the radially self-similar type and compare them with the corresponding analytical and numerical ideal-MHD solutions. The magnetic diffusivity could occur in outflows above an accretion disk, being transferred from the underlying disk into the disk corona by MHD turbulence (anomalous turbulent diffusivity), or as a result of ambipolar diffusion in partially ionized flows. We conclude that while the classical magnetic Reynolds number Rm measures the importance of resistive effects in the induction equation, a new introduced number Rb measures the importance of the resistive effects in the energy equation. We find two distinct regimes of solutions in our simulations. One is the low-resistivity regime, in which results do not differ much from ideal-MHD solutions. In the high-resistivity regime, results depart significantly from the ideal-MHD case, and seem to show some periodicity in time-evolution. Whether this departure is caused by numerical or physical reasons is of considerable interest for numerical simulations and theory of such outflows, and is currently investigated.

Bending the way of protostellar Jets

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Summary. The jets and outflows produced during star-formation are observed on many scales: from micro-jets extending a few hundred AU to the super-jets propagating to parsec distances. A class of short-lived (hundreds of nano-seconds) centimetre-long jets are now created in the laboratory as a complementary new tool to study astrophysical flows. By appropriately scaling the flow parameters, the laboratory simulated protostellar jets can be interactively tailored to include/modify rotation, magnetic fields, radiative cooling rates, etc. And may serve to test astrophysical simulations and models.

We present simulations of laboratory and astrophysical curved jets, and related laboratory experiments illustrating how the break-up of the bow-shock and the formation of knots in the flow may be produced without invoking jet variability. Additionally, we discuss the effects of rotation on the development of the observed instabilities and how to test the predictions in the laboratory. We shall also present results of using laboratory flow conditions as input to astrophysical models.

Searching for jet rotation signatures in younger Class 0 and I jets - strengthening the observational support for magneto-centrifugal ejection

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Summary. In recent years, there has been a number of detections of asymmetries in the radial velocity profile across jets from young stars. When interpreted as a rotation signature, the significance of these results is considerable. They may represent the only existing observational indications supporting the theory that jets extract angular momentum from star-disk systems. However, the possibility that we are indeed observing jet rotation in pre-main sequence systems is undergoing active debate. Given that the strength of a rotation argument lies in the survey nature of the findings, we have pursued this problem by extending our study to younger sources. Pushing the very limits of ground-based resolution, we present the latest results of a radial velocity analysis on jets from Class 0 and I sources, using data from the infrared spectragraph GNIRS on GEMINI South. These findings represent an important statistical addition to the argument for jet rotation.

Diagnostics of inhomogeneous stellar jets

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Summary. In the interpretation of stellar jet observations, the physical parameters are usually determined from emission line ratios, obtained from spectroscopic observations or using the information contained in narrow band images. The basic hypothesis in the interpretation of the observations is that the emitting region is homogeneous along the line of sight. Actually, stellar jets are in general not homogeneous, and therefore line of sight convolution effects may lead to the main uncertainty in the determination of the physical parameters.

We will show the systematic errors introduced when assuming an homogeneous medium, and we will study the effect of an inhomogeneous medium on plasma diagnostics for the case of a stellar jet.

In addition, using standard tomographic techniques we will show how to reconstruct the volumetric physical parameters of the jet. We will apply the method using observations of HH 30, showing that the reconstructed densities are much higher that the one inferred directly from the observations. Finally, we will show how using numerical simulations it is possible to determine the physical conditions of the material initially ejected from the central star-disk system.

Magnetic reconnection processes in accretion disk systems

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Summary. At the present study, we investigate the role of violent accretion and magnetic reconnection in different jet/disk accretion astrophysical systems, namely young stellar objects (YSO's), microquasars, neutron stars, and active galactic nuclei (AGN's). In the case of microquasars and AGN's, we find that violent reconnection episodes between the magnetic field lines of the inner disk region (which are established by a turbulent dynamo) and those that are anchored into the black hole are able to heat the coronal/disk gas and accelerate particles to relativistic velocities through a diffusive first-order Fermi-like process within the reconnection site that will produce relativistic blobs or plasmons. The heating of the coronal/disk gas is able to produce a steep X- ray spectrum with a luminosity that is consistent with the observations and we argue that it is being produced mainly at the foot of the reconnection zone, while the Fermi-like acceleration process within the reconnection site results a power-law electron distribution $N(E) \propto E^{-\alpha_E}$, with $\alpha_E = 2.5$, and a corresponding synchrotron radio power-law spectrum with a spectral index that is compatible with that observed during the radio flares in microquasars ($S_\nu \propto \nu^{-0.75}$). The scaling laws that we derive for AGN's indicate that the same mechanism is likely to be also operating in these sources. In the case of the YSO's, a similar magnetic configuration can be reached. The amount of magnetic energy that can be extracted from the inner disk region can heat the coronal gas to temperatures of the order of 108 K and could explain the observed X-ray flaring emission in some sources. MHD numerical simulations of these reconnection sites and the resulting particle heating and acceleration will be also presented. Finally, young neutron stars, right after the supernovae explosion that originated them, can also retain a fallback accretion disk. We argue that giant flares in SGRs can be associated to the core combustion of a neutron star having a magnetic field $\sim 10^{12}$ G and a fallback disk around it. We show that, in a timescale of $\sim$ 105 yrs, accretion from the fallback disk can increase the mass of the central object up to the critical mass for the conversion of the core of the star into quark matter. A small fraction of the neutrino-antineutrino emission

from the hot just-converted quark- matter core annihilates into electron-positron pairs above the neutron star surface originating a giant gamma flare emission (with a light curve similar to that observed, e.g., in the SGR 1806-20).

Jets from Class 0 protostars: A Spitzer - IRS view

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Summary. Collimated molecular jets from young and heavily embedded Class 0 protostars are often observed only at millimeter wavelengths. However, it is still not known whether such jets represent the cold external layer of an embedded atomic jet, or whether the jet itself is intrinsically composed of only molecular gas under low excitation conditions.

Spectroscopy in the Mid IR can shed light on the nature of the warm gas component of such jets and determine important physical conditions along their propagation axis.

We will be presenting the results of Spitzer - IRS single point and spectral mapping observations on a set of jets from Class 0 sources. The detected molecular (hydrogen) and atomic/ionic emission lines allow us to describe the excitation structure from the inner regions, close to the protostar, up to the bow shocks. We will briefly present the methods used to derive the physical parameters, and we will discuss in detail our recent findings concerning the nature of the observed jets as well as their interaction with their ambient medium.

MHD jets from different field configurations

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Summary. I will present recent results of MHD simulations of jet formation. Three different simulation setups will be considered. In the first approach the role of the disk magnetic flux profile and disk mass loss profile is investigated concerning the jet collimation degree. Our results suggest (and quantify) that in general outflows launched from a very concentrated region close to the inner disk radius tend to be uncollimated. In the second approach, jet formation is numerically investigated from a magnetic field configuration consisting of a stellar dipole plus a disk field. The central dipole is found to de-collimate the disk wind considerably. Briefly, I will also discuss the extension of the previous simulations into the relativistic regime - applicable to AGN and microquasars.

IR diagnostic of embedded jets: velocity resolved observations of the HH34 and HH46-47 jets

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Summary. We present VLT-ISAAC near-IR (NIR) medium resolution spectroscopy of the HH34 and HH46-47 jets, two bright Class I objects. Through several diagnostic lines (e.g. [FeII] 1.644 um, 1.600 um and H2 2.122 um) we probed the atomic and molecular components of the gas. In the inner jet region, the atomic emission presents a double velocity component (the so-called LVC and HVC) for both jets. The [FeII] LVC is detected up to large distances from the source (¿1000 AU), at variance with T Tauri jets. The H2 emission of the HH34 jet shows also a double velocity component near the star. The LVC and HVC are spatially separated, with no emission between both components. On the contrary, only a single velocity component is observed for the molecular emission of HH46-47. In addition, electron densities (ne) and mass fluxes have been measured separately for the different velocity components in the HH34 and HH46-47 jets. In the inner region of both jets, ne increases with decreasing velocities, while the mass flux is carried mainly by the high-velocity gas.

Hot gas in accretion disks and jets: a UV view of star formation

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Summary. No abstract has been provided.

Radiative shocks: a combined analysis from experiments and simulations

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Summary. Hypersonic flows occurring during stellar formation are known to be structured by the radiation: for instance radiative cooling is an important factor in jet collimation and contributes to shock structure occurring during the interaction of the jet with the ISM. Signatures of this coupling become spectroscopically and hydrodynamically very important in the case where the radiation is partly reabsorbed in the hydrodynamical structure, which occur in the accretion flows. Hence, whereas these accretion shocks are not directly accessible by observations, their indirect spectroscopic and photometric signatures are used to deduce accretion rate.

Such radiative shocks can now be studied in the laboratory using high-energy lasers. Using our recent laboratory experiment performed on PALS installation, and state of art multi-dimensional radiative hydrodynamics simulations, we shall present an up to date description of the radiative shocks physical and hydrodynamical properties, with emphasis on the aspects, which are important for stellar hypersonic flows.

Synthetic jets – from models to observations and back

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Summary. The main purpose of numerical simulations is to study the nature of physical processes at work in astrophysical objects.In general it is very difficult to simulate and match a particular object pixel by pixel, both due to the complex microphysics involved and due to the only insufficiently known initial and boundary conditions as imposed by the environment. Still, careful modeling and inversion of observations can unveil the structure of particular sources.

We discuss two examples: 1) inferring the magnetic field structure for the jet of M87 from synchrotron radio maps and 2) constraining the velocity field for jets from YSO through inversion of line profiles.

Recently, Gracia et al. (2005, 2008), showed, that synthetic synchrotron emission calculated from a global MHD model can reproduce the general morphology of the jet of M87. This simulations suggest, that most of the emission originates from a thin shell at finite distance from the jet axis. In the next step, we invert the radio observations across the jet using a thin shell model for the emissivity and extract the local structure of the magnetic field. Repeating this exercise at different positions along the jet constrains the global morphology of the jet's magnetic field.

Similarly, line profiles measured in jets from YSO depend on the velocity field along the line of sight. We discuss, how inversion of a series of line profiles across the jet can locally constrain the velocity field of the jet.

The cycle restarts as findings from the inversion are used to improve the global MHD simulations.

The magnetic fields of accreting T Tauri stars

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Summary. Models of magnetospheric accretion on to T Tauri stars often assume that stellar magnetic fields are simple dipoles. However, it has recently been possible, for the first time, to map the distribution of magnetic polarities across the surface of forming solar-like stars, revealing the complex nature of their magnetic fields. By extrapolating from such surface magnetograms we have reconstructed the 3D magnetic field geometry. We will show how such field structures can be used to make predictions about stellar X-ray emission properties, and will compare the field structures with that of a dipole. We demonstrate that when considering magnetic fields with a realistic degree of complexity, there is less open flux available with which to launch a stellar wind. This has important implications for models in which the angular momentum from accreting material is removed from the system by a stellar wind.

X-Ray Emission from Young Stellar Jets

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Summary. Jets from protostars and T Tauri stars define a separate and new class of X-ray sources. Weak X-ray emission has been identified in some Herbig-Haro objects ejected from protostars, but new evidence suggests X-ray emission also from microjets of classical T Tauri stars. For the prototypical case of DG Tau, the X-ray jets have been imaged with Chandra. Several further microjet-driving T Tauri stars show spectroscopic evidence for X-rays that may similarly be related to their microjets. Electron temperatures in the X-ray sources reach several million K, far higher than expected from shock heating. Alternatively, magnetic field reconnection may contribute to the heating. Electron pressures in the jet of DG Tau exceed pressures estimated for the cooler bulk gas seen in optical lines, thus suggesting that the hot plasma contributes to (transverse) jet expansion. We summarize the present status of our search for jet-related X-ray emission, present statistical correlations between jet X-ray properties and other parameters of the star-disk-jet systems, and discuss physical implications for heating and jet propagation.

X-ray Imaging Spectroscopy of Planetary Nebulae in the Era of Chandra and XMM-Newton: New Insight into Stellar Jets

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Summary. In the era of Chandra and XMM-Newton, the detection (or nondetection) of diffuse and/or point-like X-ray sources within planetary nebulae (PNe) yields important, unique insight into nebular shaping agents, including jets. Diffuse X-ray sources allow us to probe the energetic shocks within PN wind interaction regions. Meanwhile, X-ray point sources provide potential probes of magnetic fields, accretion disks, and/or binary companions at PN cores and, hence, serve as diagnostics of mass outflow launching and collimation mechanisms. In certain cases, X-ray observations of PNe can reveal the presence of jets whose presence otherwise could only be inferred indirectly. I highlight these and other recent X-ray observational results that have the potential to shed new light on the origin and evolution of the structure of PNe and, in particular, on the role of collimated outflows and jets.

Jets from stellar mass black holes

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Summary. Jets have been observed from (or inferred to exist in) X-ray binaries containing a black hole. The energy spectra and the time variability observed from such sources impose very stringent constraints on all models. To date, the majority of the proposed models treat the jet as an ornament, which simply emits radio waves. It will be demonstrated that the jet plays a central role not only in the energy spectrum (from radio to X-rays), but also in the time variability of the sources. A jet model will be presented that explains a number of very stringent observational correlations that have been seen in the best studied black-hole X-ray binary Cyg X-1.

The International Year of Astronomy 2009. An opportunity for European Astrophysicists

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Summary. The International Astronomical Union (IAU) has launched 2009 as the International Year of Astronomy (IYA2009) under the theme The Universe, yours to discover. IYA2009 marks the four hundredth anniversary of Galileo Galileis first astronomical observation through a telescope. In this context, the European Science Foundation (ESF) has decided to become an Organisational Associate of IYA2009 in order to promote Science and Astrophysics via events at European levels. After a presentation of ESF, its instruments and funding opportunities, we will present the various initiatives related to this unprecedented opportunity for the astronomical community.

Advection of Magnetic Fields in Accretion Disks

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Summary. We show that a large-scale, weak magnetic field threading a turbulent accretion disk tends to be advected inward, contrary to previous suggestions that it will be stopped by outward diffusion. The efficient inward transport is a consequence of the highly conducting surface layers of the disk, where the magnetic energy density is larger than the thermal energy density and where turbulence is suppressed.

This disk structure arises naturally in three-dimensional simulations, and we demonstrate here that it can easily support inward advection of a weak field.

The inward advection of a dipole-type magnetic field threading the disk can lead to the buildup of magnetic flux near the black hole until a maximum stationary value (on the order of equipartition) is reached, but this depends on the variations in polarity of the accreted field.

The inward advection of a quadrupole-type magnetic field can also give a dynamically significant field near the black hole, but it does not lead to the buildup of magnetic flux.

Protostellar Jet and Outflow in the Collapsing Cloud Core

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Summary. The driving mechanism of jets and outflows in star formation process is studied using three-dimensional resistive MHD nested grid simulations. Starting with a Bonnor-Ebert isothermal cloud rotating in a uniform magnetic field, we calculated cloud evolution from the molecular cloud core ($n = 10^4 cm^{-3}$) to the stellar core ($n = 10^{22} cm^{-3}$). In the collapsing cloud core, we found two distinct flows: Low-velocity flows with a wide opening angle, driven from the adiabatic core, and high-velocity flows with good collimation, driven from the protostar. High-velocity flows are enclosed by low-velocity flows after protostar formation. The difference in the degree of collimation between the two flows is caused by the strength of the magnetic field and configuration of the magnetic field lines. The magnetic field around an adiabatic core is strong and has an hourglass configuration; therefore, flows from the adiabatic core are driven mainly by the magnetocentrifugal mechanism and guided by the hourglass-like field lines. In contrast, the magnetic field around the protostar is weak and has a straight configuration owing to Ohmic dissipation in the high-density gas region. Therefore, flows from the protostar are driven mainly by the magnetic pressure gradient force and guided by straight field lines. Differing depth of the gravitational potential between the adiabatic core and the protostar cause the difference of the flow speed. Low-velocity flows correspond to the observed molecular outflows, while high-velocity flows correspond to the observed optical jets. We suggest that the outflow and the jet are driven by different cores, rather than that the outflow being entrained by the jet.

Numerical Studies for Episodic Magnetically Driven Plasma Jets

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Summary. Recent experiments performed at Imperial College on the pulsed-power MAGPIE facility have successfully shown the formation of magnetically driven radiatively cooled plasmas jets formed from radial wire arrays, which are relevant to study the launching mechanism of astrophysical jet [1]. The experiments have been now extended to study the episodic ejection (25 ns [2]) and the interaction of jets and magnetic bubbles with an ambient gas.

The dynamics of the interaction is investigated through three-dimensional resistive magneto-hydrodynamic simulations using the code GORGON [1,3]. In particular ablation of the cathodes and the possibility of current filamentation are investigated numerically to explain the periodicity and subsequent formation of multiple bubbles. Comparison with experiments is offered to validate the results. The complex structure of the magnetic field is investigated, the conservation of the magnetic flux is finally explained and the consequent confinement offered to the central jet. Furthermore the interaction of the plasma outflows with an ambient gas is investigated. The formation of shocks in the ambient gas, as well as the formation of three-dimensional Mach stems is analyzed in detail.

[1] A. Ciardi, et. al. Phys. Plasmas 14, p056501 (2007)
[2] F. A. Suzuki-Vidal, et al. 49h Annual Meeting of the Division of Plasma Physics, UO4.00007 (2007)
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Two-component jet simulations: Mixing analytical disk and stellar outflow solutions

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Summary. Theoretical arguments along with observational data of YSO jets suggest the presence of two steady components: a disk-wind type outflow needed to explain the observed high mass loss rates and a stellar-wind type outflow from the central object probably accounting for the observed stellar spin down.

Each component's contribution depends on the intrinsic physical properties of the YSO-disk system and its evolutionary stage. Understanding some of the basic properties of the interaction and co-existence of the two winds over a parameter space along with the observational implications are the main goal of this paper. Having studied separately the behavior of each type of the complementary disk and stellar analytical wind solutions in Matsakos et al. 2008, we proceed here to mix the two models together inside the computational domain.

The evolution in time is performed with the PLUTO code, investigating the characteristics of the two-component jet, the modifications each solution undergoes and the potential steady-state reached. We find that mixing the two components together results indeed in steady-state configurations with the slightly modified disk wind effectively collimating the inner stellar component. Such results are robust for all cases of the parameter space investigated and more importantly when strong variability is introduced in the stellar component.

As it will be presented, including emission in the latter case proves highly promising for the comparison with observational data.

Aspect ratio dependence in MRI shearing box simulations

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Summary. By adopting a 3D shearing box approximation with a net magnetic flux and by considering computational domains with different aspect ratios, we study the changes in the properties of turbulence driven by the magnetorotational instability as the computational domain size in the radial direction is varied relative to the height. We find that in boxes of aspect ratio unity the transport of angular momentum is strongly intermittent and dominated by channel solutions in agreement with previous work. In contrast, in boxes with larger aspect ratio, the channel solutions and the associated intermittent behavior disappear. There is strong evidence that, as the aspect ratio becomes larger, the characteristics of the solution become aspect ratio independent. We conclude that shearing box calculations with aspect ratio unity or near unity may introduce spurious effects.

Magnetospheric Accretion with Multipole Stellar Fields: Theory and Observations

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Summary. Previous analyses of magnetospheric accretion and outflow in classical T Tauri stars (CTTSs), within the context of both the X-wind model and other theoretical scenarios, have assumed a dipolar geometry for the stellar magnetic field. However, studies of hot spot covering fractions and field polarizations clearly show that the stellar magnetic field has a complex non-dipolar structure. We present here an analytic generalization of X-wind theory to include such multipolar fields. Independent of the precise geometry of the stellar magnetosphere, our generalized model makes a unique prediction about the relationship between various CTTS observables that is supported by current data, including recent detailed spectropolarimetric measurements of the hot spot size and field strength in V2129 Oph and BP Tau (Donati et al. 2007, 2008). We further investigate this issue using a superposition of multipole stellar fields that reproduce the small observed hot spot covering fraction and net surface polarization. We find that the X-wind picture indeed remains viable under these conditions, with the outflow from a small annulus near the inner disk edge little affected by the modified geometry, but with inflow highly dependent on the details of how the emergent stellar flux is linked and trapped by the inner disk regions.

Viscous resistive magnetohydrodynamic disk simulations

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Summary. We report on progress in simulating an outer standard accretion disk (SAD) surrounding an inner jet-emitting disk (JED). We present axially symmetric time-dependent simulations an accretion disk with a radially varying magnetisation distribution in the presence of both resistivity and viscosity (defined using an alpha prescription). We observe a superfast magnetosonic wind launched from the innermost region of the disk.

Molecular Cooling Effects in Large scale Simulations of Herbig Haro Objects

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Summary. Our work as part of the JETSET Marie Curie Research Network is to study the effect of molecular cooling effects on the propagation of protostellar jets. Our objective in modelling such radiatively cooling jets is to investigate issues such as the extent of the entrainment of molecular material from the ambient medium in the outflow as a possible alternative to the ejection of material directly from the disk associated with the source, as well as to explain the spectacular features observed in the infrared emissions of sources such as the HH46/47 outflow [1].

We model the jets as highly supersonic (Mach 12) inflows of gas with number density 103cm3 at a temperature of 103K into a molecular ambient medium with a number density lower by a factor of ~ 10. The gas is treated as hydrodynamic in 2D cylindrical axisymmetry using PLUTO, a modular finite volume astrophysical code [2]. In addition, we model by means of a reduced molecular network the production of H2, known to be a primary coolant in the molecular environments of forming stars. This network has been established to cover effectively the dominant gasphase formation pathways for H2 in previous work on primordial gas chemistry [3]. Dust phase reactions are not considered on the basis of arguments that gas phase reactions dominate the H2 formation at the density and temperature scales considered [4].

The chemical abundances thus obtained, allow the calculation of the atomic and molecular H2 emission losses from cooling functions, as well as enabling the production of synthetic emission maps for infrared molecular lines for comparison with observations produced by fellow members of the Jetset network. Our continuing work focusses on employing Adaptive Mesh Refinement in order to propagate to the large scales (~ 0.1 pc) of observed jets while resolving the critical shock areas satisfactorily, as well as applying results from observations to apply tighter constraints to the setup of our model.

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[2] Mignone et al., Astrophysical Journal Supplement Series 170 (2007)
[3] Abel T., New Astronomy 191 (1997)
[4] Glover S., ApJ, 331 (2003)

3D modeling of the 2006 nova outburst of RS Ophiuchi: collimated outflows and jet-like ejections

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Summary. RS Ophiuchi is a symbiotic recurrent nova that went into its latest outburst on February 2006. Chandra/HETG observations of the outburst reveal a spectrum covering a large range in plasma temperature and characterized by asymmetric and blue-shifted emission lines, suggesting a jet-like ejection, collimated by the central binary. We investigate the origin of lines asymmetries by performing 3-D hydrodynamic simulations. Our model describes the blast wave from the 2006 outburst, propagating through the inhomogeneous circumstellar medium, and takes into account all the important physical effects, namely the thermal conduction (including the effects of heat flux saturation) and the radiative cooling. We found that our model reproduces the observed X-ray emission in a natural way if an equatorial density enhancement is taken into account. The asymmetric nature of the circumstellar medium into which the early blast wave is driven leads to the shock collimation in the plane of the sky. Most of the early X-ray emission originates from a small region propagating in the direction perpendicular to the line-of-sight and localized at the interaction front between the blast wave and the equatorial density enhancement. The model predicts asymmetric and blue-shifted line profiles remarkably similar to those observed and explains the asymmetries as due to substantial X-ray absorption of red-shifted emission by ejecta material.

The survival of molecules in MHD disk winds

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Summary. Magnetohydrodynamical (MHD) models have been constructed and observations have been conducted thoroughly for atomic jets. In this work we imposed an extended molecular network on self-similar steady state MHD disk winds, in order to study the origin and formation mechanisms of molecular jets. We calculated the radiation field as coming from the star and the boundary layer; this leads to an X-ray ionization rate, that together the UV field induced photoreactions raises the ionization fraction at the base of the flow. The main heating mechanism is the drag heating between charged and neutral particles, and is balanced mainly by adiabatic and molecular cooling. Hence the temperature is maintained at low values (4000 K), and molecules are indeed able to survive. Finally, we present a set of observational predictions.

Stellar jets tomography in velocity space

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Summary. Jets are fundamental part of the star formation process, as they can help the extraction of excess angular momentum from the disk.

The physical and dynamical structure of jets can be studied through the diagnostic analysis of selected forbidden emission lines in the optical and in the infrared spectral ranges. I will show the results that we obtain by applying specialized diagnostic techniques to the observations of a sample of HH objects acquired at different wavelengths and spectral resolution. On one side the use of different spectral tracers allows us to derive the gas physical conditions (such as the electron and total density, the ionization fraction, and the temperature) both along the jet and across each shock cooling region, even if spatially unresolved. On the other side, from higher resolution data we obtain position-velocity diagrams of the physical parameters from which the jet structure in different velocity components is derived. Finally, we estimated the mass flux rate in the jet and the content of dust in the beam. As I will show these estimates can help a better definition of the parameters necessary for the development of theoretical models. Spectro-astrometric results concerning the nature of the wind at AU scales will also be presented.

Line formation in outflows from young stars

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Summary. Hydrogen lines in emission are signatures of pre-main-sequence stars and of T Tauri stars in particular. Several efforts have been done to model these lines and comparing them with observations to constrain the emission region. The strongest Hydrogen lines in near infrared part of the spectrum are those from Paschen and Bracket series which form in denser parts of the circumstellar atmosphere. They could be used as diagnostics of the inner wind close to the star in the stellar wind scenario. We compute the visibilities and line profiles of Paschen β and Bracket γ and compare the results with observations.

Flaring activity in accretion flows of YSO

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Summary. X-ray observations have shown extensive flaring activity in young stellar associations such as the Orion nebula. Observed flares are often very long and intense, and have been associated to very long magnetic loops, which may connect the stellar surface to the circumstellar disk. As such, these loops are candidate to be also the channel of star accretion from the disk, and one then wonders whether they flare during accretion flows. As a first attack to this question we have simulated with a hydrodynamic loop model flares inside long coronal loops containing plasma at high density, comparable to that presumed for accretion flows. Preliminary results show that such flares would have a very fast evolution, on time scales much smaller than the observed ones.

Can stellar jets brake efficiently T Tauri stars?

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Summary. Disk wind and X-wind models are shown to be very efficient at producing the large jet mass loading. However stellar jet models are again in fashion because there are the only way to brake down the central stars to the observed values. We shall review here how stellar jets can be combined to disk winds and how efficient MHD stellar jet are to brake the star.

Rotation observed in the molecular outflow OriS6 and its bullets

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Summary. We report on CO observations of the Ori S6 molecular outflow with both the IRAM 30m and the SMA. At either spatial resolution a velocity antisymmetry of ca. 10 km/sec (SMA) resp. 2 km/sec (30m) is clearly seen along the flow out to distances around 60" (0.15 pc) from the source; individual bullets observed near the source show the same sense and magnitude of rotation. Angular momentum can thus be transported away by jets and outflows over large distances. The amount carried in the flow is estimated to be a sizeable fraction of the total angular momentum contained in the original prestellar clump.

Large-scale 3D Simulations of Protostellar Jets: Constraining the Disk Wind Model

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Summary. I will present our latest results of three-dimensional time-dependent magneto-hydrodynamic simulations of T Tauri jets, launched magneto-centrifugally from the surface of Keplerian disk. We extend the calculations to scales probed by HST ($\sim$ 50 AU) thereby allowing a direct comparison between simulations and observations. We explore the effects of different initial magnetic field configurations on evolution and stability of these jets and focus on comparing the generated (poloidal and azimuthal) velocity profile maps with observed velocity structures.

Extending analytical MHD jet formation models with a finite outer disk radius

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Summary. The only available analytical MHD models for jets and winds are those characterized by the symmetries of radial and meridional self-similarity. Meridionally self-similar exact MHD solutions are associated with accretion-driven stellar winds (ASO, Analytical Stellar Outflow) and radially self-similar exact MHD solutions with disk-winds (ADO, Analytical Disk Outflow). However, the ADO models in general have two geometrical shortcomings, a singularity at the jet axis and the non-existence of an intrinsic scale, i.e., the jets formally extend to radial infinity. Therefore the present study focuses on imposing an outer ejecting radius of the underlying accreting disk and thus providing a finite width disk-wind (ADO). The simulations are carried out using the PLUTO code. We study the time evolution of these modified analytical models and we investigate the rich parameter space with the final goal to compare the results directly with observations.

Interaction of a Supersonic Radiatively Cooled Plasma Jet with a Background Ambient

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Summary. We will present an experimental study of the interaction of a radiatively cooled, supersonic plasma jet ($M \sim 20$) with a neutral gas. The jet used in the experiments has no dynamically significant magnetic field and is formed at early stages of a discharge of a 1MA, 250ns current pulse through a radial aluminium foil. Ablation of plasma from the foil forms a jet on its axis which interacts with the ambient gas driving a conical shock which propagates with a tip velocity of $\sim$ 60km/s. A faster moving shock starts forming at the tip of the jet, expanding with an axial velocity of $\sim$ 100km/s and interacting with both the ambient gas and the slower conical shock forming a contact surface. The contribution of the plasma ablated from the foil to the formation of the conical shock will be discussed together with results varying the initial gas composition, gas initial density and foil material.

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MHD Simulations of Radiative YSO Jets

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Summary. With the recent improvements in available observational data, simulating the radiative processes in YSO jets will provide a valuable tool for model discrimination. In Turin, we have added a radiative cooling module and time-dependent ionization state computation for 29 ion species to our MHD simulation code PLUTO. Also, post-processing routines for the realistic computation of emission lines are now available.

A first part of the presentation will focus on the description of the physics module for the radiative cooling. Then, a 1D modelling of the HH30 jet with synthetic emission line ratios computations is presented. The results are good considering the simplifications made in this model.

From 2D simulations, synthetic PV diagrams for the line emission can be directly computed, to be compared to observations. The technique and some results are shown in the last part of the presentation.

Jets in the MHD context

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Summary. Outflows in the form of jets is a widespread phenomenon in astrophysics. Their main driving mechanism is likely related to magnetic fields. These fields are able to tap the rotational energy of the central object and its surrounding disk, and accelerate and collimate matter ejecta. To zeroth order these outflows can be described within the theory of steady, axisymmetric, ideal magnetohydrodynamics (MHD). The analytical insight into the equations of the theory (mostly on the Grad-Shafranov equation which celebrates its 50th year in 2008) will be discussed. MHD offers a way to understand the jet dynamics for its acceleration, collimation and propagation, to guide related simulations, and also explain many aspects of the observations, from nonrelativistic YSO to relativistic AGN or microquasars, and highly relativistic GRB jets.

T Tauri-like Outflow Activity in the Brown Dwarf Mass Regime

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Summary. Using Spectro-astrometry, we have discovered to date, four outflows driven by brown dwarfs. Numerous accreting brown dwarfs also emit at forbidden wavelengths. Although these forbidden emission line regions are weak and confined to the source position, with specto-astrometry it is possible to recover spatial information, and thus confirm the formation of the forbidden lines in an outflow. While it is interesting to study the individual outflows the importance of this work lies mainly in how the outflows driven by sub-stellar objects compare to those driven by low mass protostars. In this talk I will review what is known so far about outflow activity in the sub-stellar regime. In particular, I will discuss our investigation of how the ratio between mass infall and outflow changes, as one moves from stellar to sub-stellar masses. In addition, images of brown dwarf outflows are needed if a comprehensive comparison is to be made with protostellar flows. I will present the initial results of an imaging study of brown dwarf outflows carried out with FORS 1 on the VLT.

Simulating the launching of YSO jets

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Summary. Nowadays it is widely accepted that the launching mechanism of jets from TTauri stars (TTS) is based on magnetohydrodynamic (MHD) processes. This kind of mechanisms can effectively accelerate the outflows and also provide a self-collimating force: this is a crucial point, since TTS do not have dense envelopes that could confine the flow. Despite a general agreement on the physics of the acceleration process, it is still debated whether the launching region is situated in the circumstellar accretion disk, on the surface of the rotating protostar, or in the region of magnetospheric interaction (or a combination of the three).

In this talk I will present numerical MHD simulations of extended disk-winds, stellar winds and magnetospheric ejections. I will depict the physical conditions which must be satisfied to launch these different types of outflows. Afterward I will describe the dynamic features (mass ejection rates, torques) which characterize these ejection phenomena. In particular I will discuss the role played by the outflows in regulating the period of rotation of the protostar.

Part III

Poster Presentations

The vortex mechanism of generation, acceleration and collimation of astrophysical jets

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Summary. On the basis of exact solutions of the hydrodynamic equations with generalization of the Rankin vortex, the vortex mechanism of generation of astrophysical streams is offered. It is shown, that occurrence of the Rankin vortex in the polar stratum of a rotating protostar causes dilatational and converging to a trunk of a vortex streams the substances providing exponential growth of angular velocity of gyration of a trunk and a pressure drop on its axis. Growth of angular velocity of gyration of a trunk of a vortex and a pressure drop on its axis stop, when jump of rotational velocity on a trunk surface reaches the sound velocity. It occurs in time ts after vortex occurrence during which the vortex motion sweeps more and more deep stratums of a cloud. Dilatational velocity of a stream along a vortex trunk thus accrues, causing the outflow of mass from a surface of a protostar as a stream eruption. Comparison of the theory to data of observations leads to satisfactory results.

Shaping Planetary Nebulae by Jets

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Summary. We report axial symmetric hydrodynamic numerical simulations of planetary nebulae shaping by jets. We use the 2D version of the VH1 hydrodynamical numerical code with radiative cooling included. We show that many different shapes can be formed by varying the jet opening angle, its velocity, its mass loss rate, and the duration of the jet active phase. The history of the AGB mass loss rate also plays a role. We can reproduce many basic structures observed in PNs, and the linear relation between distance and velocity as observed in many PNs. We compare our results with some specific PNs, and discuss the main differences and common features with jets blown by YSOs.

Accretion luminosity and accretion-ejection rate connection in Class I sources

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Summary. I will present results obtained using high resolution NIR spectroscopy (VLT-ISAAC measurements) on a sample of Class I protostars belonging to different star-forming regions. We derived the accretion luminosity ($L_{\rm acc}$) and the mass accretion rate ($\dot{M}_{\rm acc}$) of the objects using diagnostics based on the detection of photospheric absorption features observed in the spectra or, alternately, on the measurement of HI recombination emission lines, that are believed to trace accretion flows. For sources displaying jets, we investigated the ratio between $\dot{M}_{\rm acc}$ and mass ejection rate ($\dot{M}_{\rm ej}$), the latter derived from the IR emission lines observed in the spectra of their spatially-resolved jets. We found a large range of $\dot{M}_{\rm acc}$ (10^{-8} - 10^{-6} $M_\odot$/yr) and $\dot{M}_{\rm loss}$ (10^{-8} - 10^{-7} $M_\odot$/yr), indicating that Class I actually includes objects with different accretion/ejection activity. In particular, comparing the inferred $L_{\rm acc}$ with the total luminosity ($L_{\rm bol}$) of the sources (derived using recent Spitzer observations), we see that Class Is with accretion-dominated luminosities ($L_{\rm acc}/L_{\rm bol} > 0.5$) are indeed only a limited fraction. In this sense, we will discuss a set of properties that can be tentatively used to identify and characterise these actively accreting protostars, which we named ADYOs (Accretion-Dominated Young Stellar Objects), among embedded sources. As for the the inferred $\dot{M}_{\rm acc}/\dot{M}_{\rm ej}$ ratios, they span the values 0.01-0.15, in agreement with the range (0.01-0.50) expected from different MHD models. However, we note that there seems to be no strict correlation, in general, between the presence and relative intensity of accretion and ejection signatures detected in the spectra.

New Herbig-Haro Objects in the Gulf of Mexico

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Summary. The "Gulf of Mexico" is part of the dark cloud L 935, a dust lane between the North America (NGC 7000) and the Pelican Nebulae (IC 5070). All of them are part of a single HII region, W80, at a distance of about 550 pc. They are located in the northeastern end of the Great Cygnus Rift, a large complex of clouds down the same spiral arm of the Sun.

Signs of active star formation have already been found in the Gulf of Mexico, around the T Tauri stars LkHalpha 185 to 189. Herbig-Haro objects, Halpha emission-line stars and infrared excess stars were found in a previous optical and near-infrared survey covering an 7' x 14' area. New wider images obtained with the SUBARU Suprime-cam cover the whole gulf (34' x 27'). The images taken through Halpha and [SII] filters show more Herbig-Haro objects to the southwest of the region previously surveyed and increase the amount of details of the known objects.

The new HH objects will be presented as well as the analysis of the region based on all the previous images taken through optical and near infrared filters (VRI, JHK, H2, [Fe], Halpha and [SII]).

Accretion discs and rotating jets

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Summary. Jets emerge from a broad range of objects including young stellar objects, stellar black holes and active galactic nuclei. There is good evidence that all types of jets arise from the same physical process, namely accretion [Livio 1999]. Due to the compactness of the domain of interest, i.e. the innermost part of the accretion disc, it is impossible to observe the processes which produce jets in detail. Furthermore, because of the nonlinear physics (HD/MHD) dominating these regions, a numerical treatment is required to understand the triggering and launching of jets [Dal Pino, 2004]. In order to investigate the spatial morphology and dynamical behaviour of the outflows under different conditions, simulations have to start off with an accretion disc, which will then evolve into a quasi stationary accretion flow and eventually eject a jet.

Magnetorotational instability (MRI) has been shown to be the major driver of efficient transport of angular momentum in accretion discs, hence to be the originator of jet-launching. Linear stability analysis proves that in the presence of a non-vanishing r-phi-component of the dynamical stress tensor and weak magnetic fields, MRI amplifies perturbations within approximately one local orbital period and starts to transport angular momentum outwards [Balbus & Hawley, 1991]. The additional criteria needed for the transport of angular momentum are commonly fulfilled in a Keplerian accretion disc.

Accretion discs and their jets around stellar black holes on the one hand and protostellar objects on the other hand, are related to each other by the similarity of size and physical processes taking place [Livio 1999]. As there is no interaction with the central mass other than through gravity, black hole accretion discs -aside from their astrophysical importance as such- can be used as simplified models for investigating accretion onto a young stellar object [Sauty et al., 2002].

We performed direct numerical simulations of weakly magnetised plasma accreting onto a central black hole. As matter falls inwards due to MRI, it is accelerated into bipolar jet-like outflows. Remarkably, the jets eventually switch their direction of rotation. When and how this azimuthal acceleration happens, depends strongly on the geometry of the magnetic field.

We experiment numerically with different setups of the magnetic field. The applied code is PLUTO [Mignone et al., 2007], a reliable collection of Godunov type

algorithms used widely across the JETSET network. First results of this ongoing work are shown.

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Large-scale 3D Simulations of Protostellar Jets: Long-term Stability and Jet Rotation

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Summary. High resolution spectra of protostellar jets obtained by the Hubble Space Telescope (HST) during the past few years, especially those near the jet base, have made it possible for a direct comparison with jet simulation results. Of particular significance is the observed radial velocity shifts in several T Tauri jets that can be well explained by jet rotation, a natural feature of magneto-centrifugally launched disk winds. We will present our latest three-dimensional time-dependent simulations of such jets launched from the surface of Keplerian disks, as an effort to extend the calculations to the physical scale that are probed by HST. We explore the long-term stability the simulated jets were able to achieve. We generate rotation maps in a few cases, each starting with a different initial threading magnetic field configuration. We then compare them with the finest observations of jet rotation so far, and try to use the comparison to distinguish which of the chosen magnetic field configurations (and the associated mass loadings of the jet) are more realistic.

Exploring jets from young embedded protostars through velocity-resolved near-infrared spectroscopy

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Summary. We present ISAAC medium resolution (R about 9000) near-infrared spectra of a sample of H2 jets associated to young Class 0/I sources. We aim to study the physical and kinematical properties of the associated shocked regions.

From line intensity ratios of bright lines we have derived density, temperature and extinction along the jet, while from the velocity-resolved line profiles of selected lines (e.g. H_2 at 2.12 micron and [FeII] at 1.64 micron) we inferred the mass flux and variations of the different velocity components along the jet axis. This information has been used to constrain the shock physics and accretion/ejection models.

Outflow Driven Turbulence in Molecular Clouds

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Summary. Here we explore the relationship between protostellar outflows and turbulence in molecular clouds. Using 3-D numerical simulations we focus on the magnetohydrodynamics of multiple outflows interacting within a parsec scale volume. We explore the extent to which transient outflows injecting directed energy and momentum into a sub-volume of a molecular cloud can be converted into random turbulent motions and the role magnetic fields play in this process. We show that turbulence can readily be sustained by these interactions and show that it is possible to broadly characterize an effective driving scale of the outflows. We compare the velocity spectrum obtained in our studies to that of isotropically forced hydrodynamic turbulence finding that in outflow driven turbulence a power law is indeed achieved. However we find a steeper spectral index (-3) than in isotropically forced simulations (-2). We discuss possible physical mechanisms responsible for these results as well and their implications for turbulence in molecular clouds where outflows will act in concert with other processes such as gravitational collapse.

Magneto-hydrodynamic modelling of jet formation and propagation in scaled laboratory experiments

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Summary. Magneto-hydrodynamic simulations provide a powerful tool for improving our understanding of the complex physical processes underlying jet formation, launching, propagation and stability. Similar MHD calculations are also used for the design and interpretation of laboratory experiments in which supersonic radiatively cooled plasma jets are generated by applying mega-ampere currents to fine metallic wires. By designing these experiments to produce jets with similar dimensionless parameters to those found in radiatively cooled YSO jets, we ensure similarity in the non-linear evolution of the two systems. This process then allows theoretical models and numerical simulations of YSO jets to be tested in the laboratory, despite the differences in scale. Whilst the jets formed in these experiments can be largely represented using an ideal MHD approximation, in the ablating wires used to form the jets, a number of non-ideal effects are at work. These effects can include the resistive diffusion of magnetic field, thermal and radiative energy transport and features of the equation of state of dense materials. In this paper we show how experiments using conical and radial arrays of fine metallic wires can be designed to produce hydrodynamic and magneto-hydrodynamic, radiatively cooled supersonic plasma jets. Variations in the experimental configuration can be used to test the sensitivity of jet stability to the addition of angular momentum or to different magnetic field topologies, or for episodic jets. Differences in the computational approach to modelling laboratory or astrophysical scale systems are highlighted. An extension to this work is also presented in which the collision of blast waves generated by the interaction of a short pulse lasers with a cluster medium, provides a representation of the propagation of a strong shock wave through a non-uniform interstellar medium.

Jets and the structure of accretion disks

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Summary. The radial structure of accretion disks is a fundamental issue regarding star and planet formation. Many theoretical studies have been conducted in the context of the Standard Accretion Disk (SAD) model, where no jet is present. We calculate the structure of YSO accretion disks in an approach that takes into account the presence of the protostellar jets. The radial structure of these Jet Emitting Disks (JED) should then be compared to that of standard accretion disks. It is found that JEDs present a structure very different from the SADs and that can be observationally tested. The implications on planet formation in the inner regions of accretion disks are briefly discussed.

The H2 velocity field of inner knots in HH 212

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Summary. High resolution R 50 000 long-slit spectroscopy of the inner knots of the highly symmetrical protostellar outflow HH 212 was obtained in the 1-0 S(1) line of H2 at 2.12 um with a spatial resolution of 0.45 arcsec. At the resulting velocity resolution of 6 km s-1 multiple slit orientated observations of the northern first knot NK1 clearly show a double-peaked velocity field consistent with that of a radiative bow shock. In contrast, the velocity distribution of the southern first knot SK1 remains single-peaked suggesting a significantly smaller shock velocity compared to NK1. Comparison with a semi-empirical model of bow shock emission allows to constrain parameters such as the bow inclination to the line of sight, the bow shock and jet velocities for each flow. Although a few features are not reproduced by this model, it confirms the presence of several dynamical and kinematical asymmetries between opposite side of the HH 212 bipolar jet. The position-velocity diagrams of both knots exhibit complex dynamics broadly consistent with emission from a bow shock which does not exclude jet rotation although a clear signature of jet rotation in HH 212 is missing. Alternative interpretations for the variation of radial velocity across these knots such as variation in the jet orientation and jet entrainment, as well as for the velocity asymmetries between the flows are briefly considered.

Numerical simulations of knot interactions in stellar jets and comparison with observations

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Summary. Recent observations of stellar jets show a time variability in the emission and velocity of the knots along the jets, on time scales of a few years. To understand the process responsible for the production of these variabilities, we compare results obtained by numerical simulations of stellar jets with observations. The simulations include a detailed treatment of the evolution of ionic/atomic species, and the variability is assumed to be due to the interaction between knots traveling with different shock speeds and densities. We run two dimensional axisymmetric simulations changing the density and shock velocity, and three dimensional simulations changing the impact angle between the two knots as well. We produce synthetic maps for the [SII] and Halpha emission, that are deconvolved to properly take into account the instrumental effects. In these images, we measure the time variability of the knots for different parameters as velocity, luminosity and so on. Finally, our results are compared with observations.

Collisions of Magnetized Clumps in Proto-Stellar Flows

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Summary. We present axially symmetric simulations of toroidally magnetized clumps colliding in an axially magnetized environment and compare results to simulations including an adjacent side-wind, and to hydrodynamic simulations with and without a side-wind. The goal of our research is to model the dynamics internal to the beam and cocoon of an HH Jet where knots of emission are known to move relative to one another with relative velocities as high as 30 km/s.

Wide field CO(3-2) observations of the Serpens Cloud Core

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Summary. It has been shown in several studies that the thrust or momentum flux of the ouflowing material from a protostar is closely related with the luminosity of the protoselar core. In this context, molecular outflow studies offer an important way to get information on the accretion/mass ejection processes that drive the protostellar evolution.

In this poster contribution we present an area of 460x230 arcsec of the Serpens cloud core for outflow emission in the ^{12}CO(3-2) line in OTF mode with the HARP-B heterodyne detector at JCMT; CO(3-2) as a tracer outlines better molecular outflows than lower J transitions, since it is more sensitive to warm outflow than cold ambient cloud emission. In addition, CO emission traces the swept-up ambient gas that been entrained by a jet/wind that is directly linked to a protostar. Thus backtracking the outflow lobes, we can associate the outflow activity to protostellar cores. Such a homogenous dataset presents an ideal environment for the study of mass accretion and ejection properties through the study of outflow properties.

We have attributed $\sim$ 10 bipolar outflows to an equal number of Class 0/I objects, most of them being well known millimeter sources; for each one of them we have then calculated basic properties such as the column density, the total mass, momentum, kinetic energy and momentum flux of the outflows. Furthermore we have used the recent Spitzer photometric data [1] with additional mm points [2] to reconstruct the SED for the sources driving outflows. The calculated bolometric luminosity results in being $\sim$ 10 times lower than previous estimations made with ISO data [3].

Despite the details of mass accretion and ejection remain uncertain, it has been shown that the momentum flux or thrust of the outflow is correlated with the luminosity of the protostellar core [4, 5, 6]. This correlation holds also on the current dataset of Serpens, however in our presentation we discuss it in detail under the new conditions imposed from our more accurate measurements.

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Numerical simulations of Herbig Haro objects

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Summary. We have developed a new parallel, block-based adaptive mesh, hydrodynamic code. We will present some applications, in particular to Herbig-Haro objects.

R Monocerotis: a landmark for jet models

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Summary. R Monocerotis is the prototype of the Herbig Ae/Be stars driving jets. This star is therefore a unique object connecting the gap between the well studied low mass star jets and the still elusive very massive star jets. R Monocerotis drives a powerful jet which carved the reflection nebula. A unique characteristic of this jet is that it is a wiggling jet, a feature sometimes observed in PMS and extragalactic black-hole jets. In this poster the wiggling jet is presented to smaller scales and a second outflow, which was detected for the first time. We associate the second outflow to the companion and speculate that the blueshifted lobe is hitting from behind the reflection nebula causing the variability of Hubble's nebula.

Soft X-rays from DG Tau: A physical jet model

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Summary. DG Tau is a classical T Tauri star which shows an unusual X-ray spectrum, best described by two thermal components with different absorption columns. The soft X-rays are less absorbed than the hard, presumably coronal, component. This rules out stellar accretion as the origin of the soft photons and requires an emission region above the circum-stellar absorption layer. We constrain the model space from the observed X-ray parameters and, adding information from the literature, we build a physical model that interprets the X-ray emission in terms of an outflow. We find, that only a very small fraction of the total mass loss rate is required to explain the observations. We suggest that the X-rays originate from shocks in a narrow, fast inner wind component bracketted by slower outflows as observed in the optical. DG Tau also shows spatially resolved X-ray emission associated with the jet, which may be produced by the fast outflow at larger distances.

A Mid-Infrared Analysis of the High-Mass YSO IRAS11101-5829 and HH135/136

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Summary. IRAS11101-5829 is a high-mass YSO associated with a very luminous pair of herbig-haro objects HH135/136, located in Eastern Carina. Early works have pointed to a Herbig Ae/Be star encircled by a dust disk. Observations of molecular masers associated with this source apparently confirmed the high-mass nature. However, continuum mm observations revels a possible double core. Its powerful jets interact with the parent cloud sculpting a cavity. This morphology is very well defined in near-infrared. In this wavelenght region the polarization pattern is consistent with IRAS 11101-5829 being the exciting source. It has also been argued that the NE jet is deflected through a collision with a molecular cloud. The suggested location of the impact includes a MSX6C source and the knot HH136-E, which is also the center of the polarization pattern in optical wavelengths. We present mid-infrared imaging of the high-mass star forming region containing IRAS 11101-5829 and the pair of Herbig-Haro objects, using the T-ReCS instrument in Gemini South (7.7 to 12.3 micron). The high-resolution mid-infrared images confirm that the central source is a deeply embedded single high-mass star. The knot HH136-E has a SED consistent with a young stellar object embedded at parent molecular cloud. We combined these observations with previous polarization and spectroscopic data to provide a consistent picture of the region.

Multifluid simulations of the Kelvin-Helmholtz instability in protostellar jets

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Summary. The Kelvin-Helmholtz instability plays an important role in the dynamical evolution of astrophysical plasma flows. The strength and configuration of the the magnetic field are also key factors. Many numerical simulations have been carried out in order to study the interaction of this magnetic field with the plasma, however almost all have been done for the case of a 1-fluid plasma. There have been some recent numerical studies examining a multifluid plasma, but these have not yet been applied to protostellar jets. We present 2-D simulations of the Kelvin-Helmholtz instability for a 3-fluid plasma consisting of electrons, ions and neutrals. For simplicity we examine only the isothermal case, so that we can consider in detail the Hall and ambipolar resistivity and their possible effect on the structure and evolution of the jet. We present plots of the density and velocity of each plasma component, as well as the magnetic field, and compare these against plots produced in the ideal MHD case. This comparison allows us to examine the effect of such non-ideal terms on the protostellar jet.

Methanol masers in the wings of bipolar outflows driven by low-mass YSOs

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Summary. It was generally accepted that methanol masers arise only in the regions of high-mass star formation. As a result of a survey of young bipolar outflows in the regions of low-to-intermediate-mass star formation in several Class I methanol maser transitions we detected narrow features towards NGC1333I2, NGC1333I4A, HH25MMS, and L1157 B1. Flux densities of the detected lines are no higher than 11 Jy, which is much lower than the flux densities of strong maser lines in regions of high-mass star formation. Analysis shows that the narrow features are most likely masers. This conclusion was confirmed by subsequent VLA observations of L1157, which showed that the narrow line is emitted by a compact, undoubtedly maser source located near the terminal point of high-velocity jet.

Extragalactic jets with helical magnetic fields: relativistic MHD simulations

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Summary. Extragalactic jets are inferred to harbor dynamically important, organized magnetic fields which presumably aid in the collimation of the relativistic jet flows. We here explore by means of grid-adaptive, high resolution numerical simulations the morphology of AGN jets pervaded by helical field and flow topologies. We concentrate on morphological features of the bow shock and the jet beam behind the Mach disk, for various jet Lorentz factors and magnetic field helicities. We investigate the influence of helical magnetic fields on jet beam propagation in overdense external medium. We use the AMRVAC code, employing a novel hybrid block-based AMR strategy, to compute ideal plasma dynamics in special relativity. The helicity of the beam magnetic field is effectively transported down the beam, with compression zones in between diagonal internal cross-shocks showing stronger toroidal field regions. In comparison with equivalent low-relativistic jets which get surrounded by cocoons with vortical backflows filled by mainly toroidal field, the high speed jets demonstrate only localized, strong toroidal field zones within the backflow vortical structures. We find evidence for a more poloidal, straight field layer, compressed between jet beam and backflows. This layer decreases the destabilizing influence of the backflow on the jet beam. In all cases, the jet beam contains rich cross-shock patterns, across which part of the kinetic energy gets transferred. For the high speed reference jet considered here, significant jet deceleration only occurs beyond distances exceeding order 100 jet radii, as the axial flow can reaccelerate downstream to the internal cross-shocks. This reacceleration is magnetically aided, due to field compression across the internal shocks which pinch the flow.

Jets from Collapsing Stars

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Summary. The formations of relativistic jets by stellar collapse are considered. These jets will form in the polar caps of magnetosphere, when a stellar magnetic field increases during collapse and the charged particles will accelerate. These jets will generate the non-thermal radiation. The analysis of particle dynamics and its emission in the stellar magnetosphere under collapse show that the collapsing stars can by powerful sources of the jets and the non-thermal radiation. The radiation flux grows with decreasing stellar radius and can be observed in the form of radiation burst with duration equal to the stellar collapse time. This radiation can be observed by means of modern astronomical instruments.

A quest for infall and outflow in a sample of massive star forming regions

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Summary. Establishing the initial conditions for massive star formation is a difficult task because massive stars form in dense clusters and interact strongly with their surroundings through powerful winds and emission of large amounts of ionising photons. Therefore, in order to improve our understanding of massive star formation, it is important to study molecular cores containing high-mass Young Stellar Objects still in a very early evolutionary phase.

As part of a larger project aimed at studying the kinematics of the early phases of high-mass star formation at different spatial scales, a sample of molecular clumps hosting massive YSOs has been mapped in the ^{13}CO (2-1) and C^{18}O (2-1) lines with the IRAM-30m telescope (Granada). The purpose is to search for massive molecular outflows as well as signatures of infalling motions, characterise their properties and analyse the relation between infall and outflow. The sample has been selected so as to favour the earliest evolutionary phases of star formation. Maps and results derived from these observations will be presented and discussed.

The angular momentum of dense clumps in elephant trunks

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Summary. At the head of an elephant trunk, the interaction of the shock (driven by the photoevaporation process) with previously existing density perturbations leads to the formation of dense clumps. Some of these clumps have enough mass to be autogravitating, and therefore can eventually form new stars. We carry out a 3D simulation of this process, and from the results we compute the angular momenta of these collapsing clumps. We show that the angular momenta of the clumps have preferential directions, which in principle indicate the directions in which jets will eventually be ejected from the star+accretion disk systems that are being formed.

Experimental results to study astrophysical jets using Intense Lasers

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Summary. We present an experimental characterization of jet propagation in vacuum and in an ambient medium. An intense laser was used to generate a strong shock through a foam filled cone target. The obtained results for the jet shape, temporal evolution and density are presented. As in previous experiments, we demonstrate here the importance of implementing several diagnostics to measure the required parameters, in order to infer the relevant dimensionless scaling parameters.

We observed, with an interferometry diagnostic and with proton radiography, a perturbation in the interaction region between the jet and the ambient medium. The effect of the ambient medium on the jet velocity is also presented.

A precessing jet in the NGC2264G outflow

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Summary. We present new infrared imaging of the NGC2264G protostellar outflow region, obtained with the InfraRed Array Camera (IRAC) on-board the Spitzer Space Telescope. A jet in the red outflow lobe (eastern lobe) is clearly detected in the IRAC bands and, for the first time, is shown to continuously extend over the entire length of the red outflow lobe traced by CO observations. The red-shifted jet also extends to a deeply embedded Class 0 source, VLA 2, confirming previous suggestions that it is the driving source of the outflow (Gomez et al. 1994). The images show that the easternmost part of the red-shifted jet exhibits what appear to be multiple changes of direction. To understand the red-shifted jet morphology we explored several mechanisms that could generate such apparent changes of direction. From this analysis, we conclude that the red-shifted jet structure and morphology visible in the IRAC images can be largely, although not entirely, explained by a slowly precessing jet (period 8000 yr) that lies mostly on the plane of the sky. It appears that the observed changes in the red-shifted jet direction may be sufficient to account for a significant fraction of the broadening of the outflow lobe observed in the CO emission.

Line Diagnostics of Outflows from Classical T Tauri Stars

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Summary. How outflows may influence their parental cloud remains a fundamental question in star formation. How efficiently are energy and momentum transferred from the outflow to its environment and thus how capable is the outflow of helping to support the cloud under gravitational collapse?

Optical outflows which are comparable in length of the size of their parent cloud have been observed from a number of Classical T Tauri stars. Proper motions studies reveal that these outflows have tangential velocities of $\sim$ 200km/s. Recently, the "BE" method has been applied to these outflows. Using this method it is possible to determine fundamental parameters, through forbidden emission line analysis, as electron density, ionisation fraction and excitation temperature of shocks in the outflow. These parameters, in combination with the previously calculated proper motions, allow us to estimate the mass-loss rates of these outflows. These rates can then be used to estimate the extent to which outflows may affect their surrounding environment in terms of energy and momentum injection in to the clouds.

Transverse stability of relativistic two-component jets

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Summary. Astrophysical jets from various sources seem to be stratified, with a fast inner jet and a slower outer jet. As it is likely that the launching mechanism for each component is different, their interface will develop differential rotation, while the outer jet radius represents a second interface where disruptions may occur. We explore the stability of stratified, rotating, relativistic two-component jets, in turn embedded in static interstellar medium. In a grid-adaptive relativistic hydrodynamic simulation with the AMRVAC (Adaptive Mesh Refinement version of the Versatile Advection) code, the non-linear azimuthal stability of two-component relativistic jets is investigated. We simulate until multiple inner jet rotations have been completed. We find evidence for the development of an extended shear flow layer between the two jet components, resulting from the growth of a body mode in the inner jet, Kelvin-Helmholtz surface modes at their original interface, and their nonlinear interaction. Both wave modes are excited by acoustic waves which are reflected between the symmetry axis and the interface of the two jet components. Their interaction induces the growth of near stationary, counterrotating vortices at the outer edge of the shear flow layer. The presence of a heavy external jet allows their further development be slowed down, and the maintaince of a collimated flow. At the outer jet boundary, small-scale Rayleigh-Taylor instabilities develop, without disrupting the jet configuration.

We demonstrate that the cross-section of two-component relativistic jets, with a heavy, cold outer jet, is non-linearly stable.

The physical properties of the RW Aur bipolar jet from HST/STIS high-resolution spectra

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Summary. We present the results of HST/STIS high-resolution long-slit spectral observations of the T Tauri star RW Aur jet. A set of the spectra containing forbidden doublets [O I] 6300,6363, [S II] 6716,6731, [N II] 6548,6583 was used to determine electron density and temperature, ionization fraction, total hydrogen density, radial velocity and the mass flux along both red- and blueshifted jets of RW Aur. We have extracted the parameters up to 3.9 arcseconds in red- and up to 2.1 arcseconds in blueshifted beam. Our results show that the RW Aur jet seems to be one of densest object than studied before, but other properties are quite similar to those of other T Tauri jets. Taking into account that RW Aur is a very strong accretor, we suggest that the jet density (i.e. the amount of ejected material) may be linked to the intensity of the accretion processes. The derived parameters allow a direct comparison with other T Tau jets that brings information useful to test current models of ejection mechanism.

Stability of Magnetized Spine-Sheath Relativistic Jets

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Summary. In order to investigate the stability of magnetized spine-sheath relativistic jets, we have performed 3D RMHD simulations of weakly and strongly magnetized relativistic jets embedded in a weakly and strongly magnetized stationary or mildly relativistic ($0.5c$) sheath flow using the RAISHIN code. In the numerical simulations a jet with Lorentz factor $\gamma = 2.5$ is precessed to break the initial equilibrium configuration. Results of the numerical simulations are compared to theoretical predictions from a normal mode analysis of the linearized RMHD equations describing a uniform axially magnetized cylindrical relativistic jet embedded in a uniform axially magnetized sheath flow. The prediction of increased stability of a weakly-magnetized system with mildly relativistic sheath flow to Kelvin-Helmholtz instabilities and the stabilization of a strongly-magnetized system with mildly relativistic sheath flow is confirmed by the numerical simulations.

Chemical Models of Hot Molecules at Shocks in Outflows

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Summary. It is observationally known that outflows are associated with many young stars, and they are thought to originate from accretion disks around the stars. Meanwhile, molecular line observations have shown that some molecules such as CH3OH and SiO are very abundant at shocks and/or clumps in outflows.

In this work we have constructed chemical models at shock fronts in outflows by calculation time-dependent gas-phase reactions which are initiated by evaporation of icy mantle molecules on dust grains. We have studied dependences of the chemical structure at the shocks on different physical conditions to show that a variety of molecular abundance ratios can be obtained, owing to the dependence of dissociation rates on gas temperature and of adsorption rates on dust temperature. The physical properties at the upstream of the outflow also affects the abundance ratios.

Survival of H2 and CO MHD disk winds in class 0, class I and class II stars

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Summary. We report our results on a model of self-similar disk winds, aimed at constraining the origin of molecular jets from young stars. We computed the thermal properties, ionization structure and chemical evolution, after we imposed an extended molecular chemical network of species and reactions.

With the inclusion an appropriate radiation field coming from the star itself and hot spots on its surface, our model produces an ionization fraction high enough in order to maintain the drift speed between charged and neutral particles in low values. As a consequence, the model produces a temperature plateau 2000 K, and molecules are able to survive.

Amongst the reactions that dominate the chemical state of the gas are the collisional ionization, and the photodissociation of H2 and CO, in which we take into account their self-shielding. We present results for typical class 0, class I and class II stars, and we explore the effect of the anchor point on the molecular abundances.

Three-fluid plasmas in star formation

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Summary. Interstellar magnetic fields influence all stages of the process of star formation, from the collapse of molecular cloud cores to the formation and evolution of circumstellar disks and protostellar jets. This requires us to have a full understanding of the physical properties of magnetized plasmas of different degrees of ionization for a wide range of densities and temperatures.

We derive general equations governing the magneto-hydrodynamic evolution of a three-fluid medium of arbitrary ionization, also including the possibility of charged dust grains as the main charge carriers (Pinto, Galli & Bacciotti 2008, A&A, Vol.484, pp.1-15).

We complement this analysis computing accurate expressions of the collisional coupling coefficients for a variety of gas mixtures relevant for the process of star formation (Pinto & Galli 2008, A&A, Vol.484, pp.17-28). Over spatial and temporal scales larger than the so-called large-scale plasma limit and the collision-dominated plasma limit, and for non-relativistic fluid speeds, we derive an advection-diffusion equation for the evolution of the magnetic field and general expressions for the resistivities, the diffusion timescales and the heating rates in a three-fluid medium and we use them to estimate the evolution of the magnetic field in molecular clouds and protostellar jets (Pinto, Galli & Bacciotti 2008).

A systematic method for finding radially self-similar solutions for astrophysical jets

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Summary. We study an exact model of radially self-similar magnetohydrodynamic outflows appropriate to describe collimated jets from astrophysical systems with accretion disks spiraling around a central gravitating object. The mathematical problem is reduced to the integration of a set of nonlinear ordinary differential equations. A physically accepted solution needs to cross several critical surfaces whose knowledge is not known a priori but depends on a number of physical parameters. We search for the right combinations of those 10 parameters which produces solutions crossing the modified fast critical surface, satisfying thus causality.

We use a numerical algorithm that tests a pre-defined range of values in the 10-dimensional parameter space, classifies the derived solutions and tunes one parameter in each combination so that this solution reaches the modified fast critical surface. We then continue across this critical surface, demanding that this crossing is very smooth.

The results are discussed in the context of the launching and collimation properties of magnetohydrodynamic disk-winds and jets associated with young stellar objects in star formation regions.

Physical conditions of the shocked regions in planetary nebulae

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Summary. In the past decate high resolution optical images have revealed the wide morphological variety of symmetric collimated structures in planetary nebulae (PNe): multipolar lobes, jets, low-ionization knots, among other fascinating microstructures. These outflows reach velocities of several hundred km/s and show evidences of shocked excitation. I will present a review of the observational evidence for shock-excited regions in PNe, examine their physical conditions and describe the expected properties of shock-excited structures irradiated by the PN central star.

The jets of the Proto-planetary nebula CRL 61

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Summary. We present a study of the structure and kinematics of the proto-planetary nebula CRL 618 based on STIS HST archival long-slit spectroscopic observations. We aim to examine the kinematic structure and the physical conditions of the lobes of CRL 618 at high spatial resolution. We find that at certain positions along the lobes, the radial velocity increases with the distance to the source. The physical conditions of the lobes of CRL 618 have been determined better than ever, showing sudden changes in excitation in small spatial scales.

The formation of filamentary structures in radiative cluster winds

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Summary. We explore the dynamics of a "cluster wind" flow in the regime in which the shocks resulting from the interaction of winds from nearby stars are radiative. We first show that for a cluster with T Tauri stars and/or Herbig Ae/Be stars, the wind interactions are indeed likely to be radiative. We then compute a set of four three-dimensional, radiative simulations of a cluster of 75 young stars, exploring the effects of varying the wind parameters and the density of the initial ISM that permeates the volume of the cluster. These simulations show that the ISM is compressed by the action of the winds into a structure of dense knots and filaments. The structures that are produced resemble in a qualitative way the observations of the IRAS 18511+0146 of Vig et al. (2007).

Hydrodynamical modelling of the accretion shock on CTTSs and its X-ray emission

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Summary. Recent high spectral resolution ($R \sim 600$) X-ray observations of some young accreting objects, show the presence of plasma denser (10^{11}–10^{13} cm^{-3}) and colder (2×10^6 K) than the X-ray emitting plasma usually present in the stellar coronae. This component is likely due to the shock-heated material produced by the interaction between the accretion flow and the stellar atmosphere.

We are carrying out new 1D hydrodynamic simulations describing the impact of an accretion flow onto the stellar chromosphere. Our simulations include the effects of radiative cooling, thermal conduction and gravity and a detailed modelling of the chromosphere. We will discuss the preliminary results of our simulations and the comparison with the X-ray observations of CTTSs.

Radial and Vertical angular momentum transport in protostellar disks

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Summary. Angular momentum transport in protostellar disks can take place radially, through MHD turbulence induced by the magnetorotational instability (MRI), or vertically, via outflows accelerated centrifugally by large-scale magnetic fields that thread the disk. It is likely that the relative importance of these two mechanisms changes with location and with the evolutionary stage of the system. Furthermore, in these objects the low ionization fraction of the gas affects the field-matter coupling and the magnetic diffusivity can be high enough to limit or even suppress these processes. As a result, it is imperative that realistic models account for the disk radial and vertical structure and for the departure from ideal-MHD fluid conditions.

We have investigated these angular momentum transport processes taking into account the detailed ionization structure of the disk as a function of distance from the central protostar, as well as its vertical stratification, and including all relevant field-matter diffusion mechanisms (ohmic, hall and ambipolar). In this contribution we will examine the viability and properties of magnetically driven outflows from the surfaces of realistic protostellar disks, present strong field solutions in which the angular momentum transport is purely vertical via winds launched from the inner regions ($R \leq 10$ AU) of disks as well as illustrative intermediate field strength solutions in which both radial and vertical transport mechanisms operate. The implications of the resulting disk structure to planet formation and migration are briefly discussed.

The nature of the soft X-ray source in DG Tau

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Summary. The classical T Tauri star DG Tau shows the typical signatures of X-ray activity and, in particular, harbors a resolved X-ray jet. We show that its soft and hard X-ray components are spatially separated by approximately 0.2 arcsec by deriving the spatial offset between both components from the event centroids of the soft and the hard photons utilizing the intrinsic energy-resolution of the *Chandra* ACIS-S detector. We also demonstrate that this offset is physical and cannot be attributed to an instrumental origin or to low counting statistics. Further, the location of the derived soft X-ray emission peak coincides with emission peaks seen in optical emission lines, suggesting the same origin for the material radiating in soft X-rays and optical emission lines.

Formation of Magnetically Driven Radiatively Cooled Plasma Jets in the Laboratory

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Summary. Previous experiments have successfully showed the formation of magnetically driven radiatively cooled plasma jets which are relevant to the launching of astrophysical jets. The jets in these experiments are driven by the pressure of the toroidal magnetic field produced by the MAGPIE generator which leads to the formation of a magnetic tower structure. This scenario is characterized by the formation of a magnetic bubble surrounding a collimated plasma jet on axis. A modification of this experimental configuration, in which radial wire array is replaced by radial metallic foil, results in the formation of episodic magnetic tower outflows which emerge periodically on timescales of 30ns. The subsequent magnetic bubbles propagate with velocities reaching 300km/s and interacting with previous eruptions leading to the formation of shocks. This research was supported by the European Communitys Marie Curie JETSET network (contract MRTN-CT-2004 005592) and the SSAA program of the NNSA (DOE Cooperative Agreement DE-FC03-02NA00057).

Verification of candidate protostellar outflows in GLIMPSE

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Summary. Using the 4.5 micron excess emission as a tracer of shocked molecular hydrogen, we identified more than 150 candidate protostellar outflows in GLIMPSE. In order to verify their nature as well as to study their morphology at higher resolution, a follow-up campaign for 2.12 micron narrow-band imaging was initiated. This contribution presents first results for southern objects obtained with SOFI at the ESO NTT. More than half of targets could be detected. The non-detections point to large dust column densities and/or different excitation conditions. We discuss the flow morphology, and the occurrence of multiple flows in our target fields.

Young Stellar Micro-Jets and Outflows in the Massive Star Forming Complex W5

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Summary. W5 is an active region of star formation located at 2 kpc in the Perseus spiral arm within Cassiopeia. The western region of W5 (W5W) is defined by a large 1.5 degree diameter HII region rimmed by bright molecular clouds. The eastern component W5E is similarly characterized, extending about 1 degree in diameter. W5E is predominately ionized by a single O7 star, while W5W has several O-stars ionizing the region. We have surveyed W5 in the optical (Ha, [S II], and i filters) using the KPNO 4m wide-field MOSAIC camera, and at 1.1mm using Bolocam on the Caltech Sub-Millimeter Observatory on Mauna Kea. Our surveys covered several square degrees (and included other nearby star forming complexes). Several highly collimated, compact stellar micro-jets were discovered, along with other interesting outflows and Herbig-Haro objects. We have obtained optical spectra with the ARC APO 3.5m telescope at various position angles of several of these jets and outflows. The spectra reveal high jet velocities around 200 km/s. Details on the observations for some of these jets will be presented. The dynamics and morphology of the regions in which they have formed will be discussed, and relate how this bears on the formation of YSOs and jets.

Water Masers and Radio Continuum Emission Tracing Thermal Radio Jets

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Summary. We present interferometric observations of radio continuum and water maser emission carried out with the VLA toward five massive star-forming regions. Radio continuum sources were detected toward all star-forming regions and some of them could be thermal radio jets. In addition, although water maser emission was found in all massive star-forming regions, the water masers are not spatially associated with all detected continuum sources. Based on the analysis of the distribution of water masers and the characteristics of the continuum emission, we suggest that some water masers are tracing jets.

Parameter Study in Disk-Jet systems. A focus on magnetization

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Summary. Many objects that stellar and extragalactic astronomy study fall into the category of accretion ejection systems. In the last years numerical simulations have focused their interest in such systems, probing into their mechanisms in an attempt to better comprehend the underlying physics.

In this work we study the effects of magnetization and anisotropic diffusion on a sub-keplerian resistive accretion disk driving an ideal, magnetised outflow. Issues like ejection efficiency, angular momentum and energy transport, stability and the system's ability to reach an enduring steady state are addressed.

With these in mind, we present a series of 2.5D axisymmetric MHD simulations performed using the finite volume, shock capturing code, PLUTO.

We obtain the expected solutions for magnetization near equipartition. The extreme cases with either strong or weak magnetic field configuration prove deficient in various aspects which are displayed. Also the accretion-ejection dynamics for all configurations are discussed.

Effects of flaring activity on the dynamics of accretion discs in YSOs

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Summary. Many young stellar objects show strong flare activity. Here we investigate the effects of strong flares (occurring on the stellar corona) on the accretion disk and, presumibly, on accretion phenomena in YSOs. We present a MHD model describing the occurrence of an unconfined flare on a rotating magnetized star surrounded by a Keplerian disk with an aligned dipole moment. The model takes into account all the important physical effects, namely the magnetic-field-oriented thermal conduction, the radiative losses from optically thin plasma, and the gravity. The model is implemented using the MHD code PLUTO. We study the global dynamics of the system exploring the space of relevant parameters, namely the position and intensity of the heating release triggering the flare.

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The Antikythera Mechanism is an ancient mechanical calculator consisting of 30 gears (also described as the first "mechanical computer") designed to calculate astronomical positions with remarkable detail. It was discovered in the Antikythera wreck off the Greek island of Antikythera, between Kythera and Crete, in 1900, and is considered to be one of the most important archeological artifacts ever found. The Mechanism is believed to have been constructed in Rhodes around 150-100 BC. Technological achievements of similar complexity did not reappear until a thousand years later.

`http://www.antikythera-mechanism.gr`

Hipparchus was born at Nicea in Bithynia at 190 or 194 B.C. and left when he was around 30 year old for Rhodes Island. There he spent most of his life and died around 120 BC. He founded his own Observatory and wrote a great number of works on astronomy, mathematics, geography and meteorology. Hipparchos is considered by many researchers as the most important astronomer and geographer of Antiquity. He constructed and improved several astronomical instruments which he used for his observations. It is also believed that he built the Antikythera Mechanism.

The most important and well known of his discoveries are: i) The compilation of a catalogue including accurate positions of 1020 stars, classified into six groups according to their brightness or apparent magnitude. ii) The phenomenon of precession of the equinoxes. iii) The calculation of the tropic year length to be 365 days 5hrs 55min 12sec, and the length of the mean lunar month 29d 12hrs 44min and 2.5sec. iv) Hipparchus adopted the geocentric system and used the eccentric circles and later the one of epicycles to model the orbits of the Sun and moon. v) Hipparchus calculated the inclination of the moons orbit in relation to the ecliptic. vi) Finally, Hipparchus improved Aristarchus estimates of the diameters and distances of the Sun and moon from earth.