DYNAMICAL FERMION MASS GENERATION BY A STRONG YUKAWA INTERACTION

Jiří Hošek, NPI Řež (Prague)

Tomáš Brauner and Jiří Hošek, hep-ph/0505231

$$\mathcal{L} = \bar{\psi}_L i\partial\!\!\!/ \psi_L + \bar{\psi}_R i\partial\!\!\!/ \psi_R + (\partial_\mu \phi)^\dagger \partial^\mu \phi - M^2 \phi^\dagger \phi - -\frac{1}{2}\lambda(\phi^\dagger \phi)^2$$

$$+ y\bar{\psi}_L \psi_R \phi + y\bar{\psi}_R \psi_L \phi^\dagger$$

- Global chiral $U(1)_L \times U(1)_R$ symmetry

$\Psi_{L,R} \rightarrow \exp[i\alpha_{L,R}]\,\Psi_{L,R}$, $\Phi \rightarrow \exp[i(\alpha_L - \alpha_R)]\,\Phi$

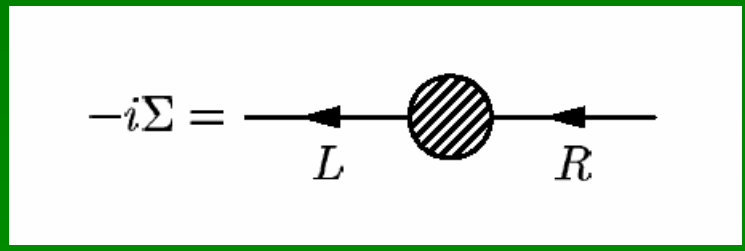
FERMION MASS TERM PROHIBITED

NO SCALAR-FIELD CONDENSATION ($M^2 > 0$)

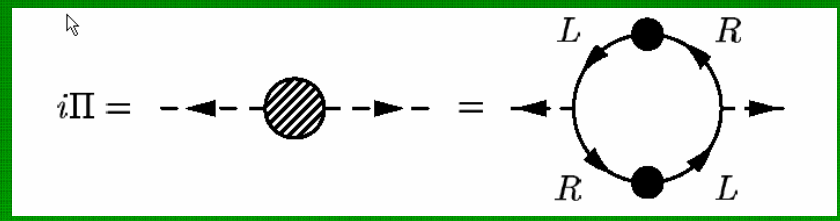
Results

- Fermion acquires a mass expressed in terms of UV-finite solution of the SD equation for full fermion propagator
- Complex scalar field Φ describes two real scalar particles with different masses
- There is a massless pseudoscalar NG boson as a collective excitation of both fermion and boson fields

Assume chirality-changing Σ is dynamically generated

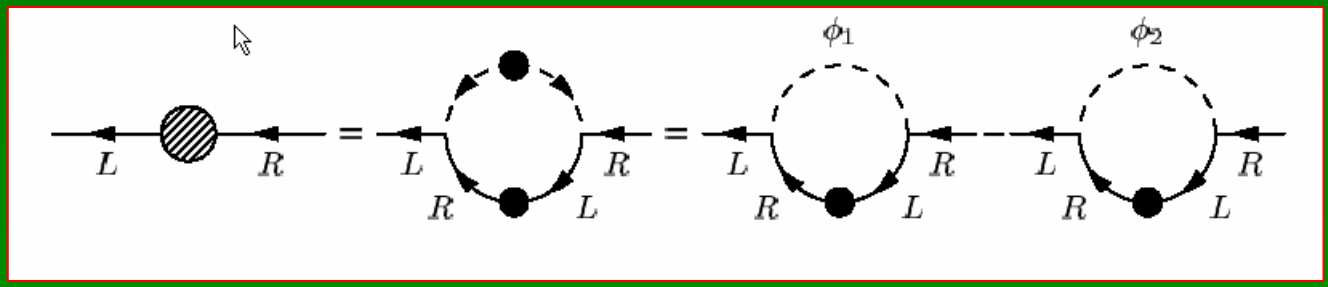


- Σ induces generically new chiral-symmetry breaking Π in the scalar sector

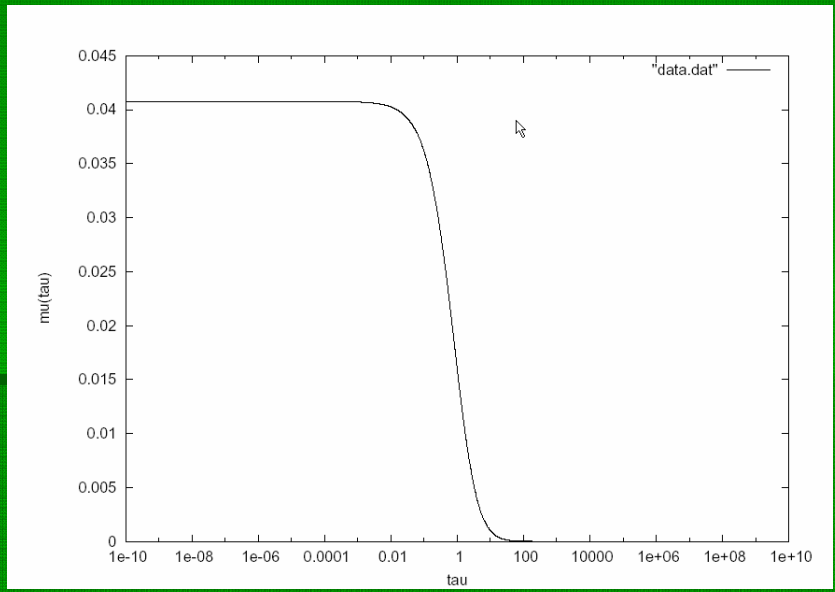


$$\mathcal{L}'_{0\phi} = (\phi^\dagger, \phi)\, D^{-1}(p) \begin{pmatrix} \phi \\ \phi^\dagger \end{pmatrix} = \frac{1}{2}\phi_1(p^2 - M^2 - \Pi)\phi_1 + \frac{1}{2}\phi_2(p^2 - M^2 + \Pi)\phi_2$$

$$D(p) = \frac{1}{\left(p^2 - M^2 - \Pi(p^2)\right)\left(p^2 - M^2 + \Pi(p^2)\right)} \begin{pmatrix} p^2 - M^2 & i\Pi \\ -i\Pi & p^2 - M^2 \end{pmatrix}$$



- SCHWINGER-DYSON EQUATION FOR Σ
- If Σ exists it is UV finite and dominated at low momenta



- Numerical evidence for critical value of the coupling
- Substitution of Σ in SD equation for Π results in Π which is also UV finite and dominated at low momenta

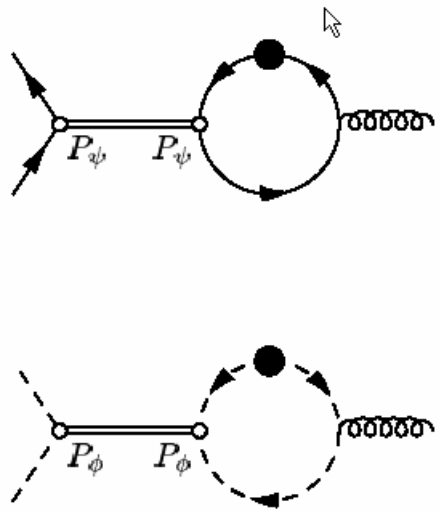
WHERE IS THE NAMBU-GOLDSTONE BOSON ?
GLOBAL CONTINUOUS AXIAL SYMMETRY IS SPONTANEOUSLY BROKEN

$$j_A^\mu = \bar{\psi}\gamma^\mu\gamma_5\psi + i\left[(\partial^\mu\phi)^\dagger\phi - \phi^\dagger\partial^\mu\phi\right]$$

$$\partial_\mu j_A^\mu = 2im\bar{\psi}\gamma_5\psi + (M_1^2 - M_2^2)\phi_1\phi_2$$

$$\Gamma^\mu_{A\psi,\mathrm{pole}}(p+q,p) = \left[\Sigma(p+q) + \Sigma(p)\right]\gamma_5\frac{q^\mu}{q^2}$$

$$\Gamma^\mu_{A\phi,\mathrm{pole}}(p+q,p) = \left[\Pi(p+q) + \Pi(p)\right]\frac{q^\mu}{q^2}$$



CONCLUSIONS

- Massless pseudoscalar Nambu-Goldstone boson is a collective excitation of both fermion and boson fields with couplings calculable in terms of Σ and Π.
- Detailed knowledge of Σ and Π in Minkowski space is necessary.
- Gauging $U(1)_A$ (with care due to anomaly) should result in massive axial-vector field with mass calculable in terms of Σ and Π.
- Generalization to anomaly-free gauge SU(2)xU(1) chiral electroweak theory in
- Tomáš Brauner and Jiří Hošek, hep-ph/0407339 (with bosonic admixture of the ‘would-be’ NG bosons regrettably omitted).