# Deconfinement in (2+1) D Georgi Glashow

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# Introduction

- Why?
- What?
- How?

# Theory

- $S = -\frac{1}{2g^2}\int d^3x Tr(F_{\mu\nu}F^{\mu\nu}) + \int d^3x \left[\frac{1}{2}(D_\mu h^a)^2 + \frac{\lambda}{4}(h^a h^a - v^2)^2\right]$
- $A_\mu = \frac{i}{2}A^a_\mu \tau^a$, $h = \frac{i}{2}h^a\tau^a$, $F_{\mu\nu} = dA + [A_\mu, A_\nu]$
- Weak coupling, $v >> g^2$
- $SU(2) \rightarrow U(1)$ with $M_H^2 = 2\lambda v^2$, $M_W^2 = g^2 v^2$

# Dual Theory

Condansate

$$\mathcal{L}_{eff} = \frac{g^2}{8\pi^2 T}(\partial_\mu \chi)^2 + \zeta cos2\chi + \mu cos\tilde{\chi}$$

$$M^2 = \frac{16\pi^2\xi}{g^2} \qquad \xi \propto e^{-4\frac{\pi M_W}{g^2}\epsilon}$$

Here $\tilde{\chi}$ is dual to $\chi$

$$i\partial_\mu \tilde{\chi} = \frac{g^2}{2\pi T}\epsilon_{\mu\nu}\partial^\nu \chi$$

# Order Parameters

- $P(x)$ as an order parameter
- $Z(N)$ breaking $\iff$ deconfinement
- $P(x) \to zP(x)$
- $\langle P(x) \rangle = e^{-\beta F_q}$
- $\langle P(x) \rangle = 0$ at high temperature due to $Z(N)$ restoration whereas $\langle V(x) \rangle \neq 0$ due to vortex condensation.

# Thermal Compactification

- Wick Rotation
- Thermal compactification
- Dimensional Reduction
- Bosonization!

# Bosonization

- $\mathcal{L}_T = \bar{\psi} i \gamma^\mu \partial_\mu \psi - \frac{g}{2} j^\mu j_\mu - m' Z \bar{\psi} \psi$
- $\mathcal{L}_{SG} = \frac{1}{2} \partial^\mu \phi \partial_\mu \phi + \frac{\alpha_0}{\beta^2} cos \beta \phi$

$$4\pi/\beta^2 = 1 + g/\pi \tag{1a}$$

$$-\beta/2\pi\epsilon^{\mu\nu}\partial_\nu \phi = j_\nu \tag{1b}$$

$$\alpha_0/\beta^2 cos\beta\phi = -m'\sigma \tag{1c}$$

# Fermionization

- Soliton operators

$$\psi_1(x) = Aexp\Big\{ -\frac{2\pi i}{\beta}\int_{-\infty}^{x} d\lambda \dot{\phi}(\lambda) - \frac{i}{2}\beta\phi\Big\}$$
$$\psi_2(x) = Aexp\Big\{ -\frac{2\pi i}{\beta}\int_{-\infty}^{x} d\lambda \dot{\phi}(\lambda) + \frac{i}{2}\beta\phi\Big\}$$

- $P = Aexp(-i\pi \int J^{05})$, $V = Aexp(-i\pi \int J^{0})$ in terms of fermionic DOF
- vortex background $\rightarrow$ zero modes!

# Observables

- $<>= 0 \rightarrow$ normalizable zero modes
- $\langle VV^* \rangle$, $\langle VV \rangle$, S...
- Functional determinant $\rightarrow$ sub determinant in zero mode basis

# References


- Mandelstam, S. Phys Rev D 11, 3026 (1975)
- Dunne, G et al. Deconfining Phase Transitions in 2+1 Georgi Glashow. (2001)
- Coleman, S. Phys. Rev. D. 11, 8 (1975).

Thank you.