

# Worldsheet Instanton Corrections to the Kaluza-Klein Monopole

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with J. Harvey: [hep-th/0507204](https://arxiv.org/abs/hep-th/0507204)

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# Studying T-Duality via Monopoles

- General motivation: understand T-duality
  - Parallel treatment of momentum, winding
- Specific: monopoles in duality web
- Correct solution important for calculations

# Kaluza-Klein Monopole

$$ds^2 = H(r) d\vec{r} \cdot d\vec{r} + H(r)^{-1} \left( d\kappa + \frac{1}{2} \vec{\omega} \cdot d\vec{r} \right)^2$$

$$H(r) = \frac{1}{g^2} + \frac{1}{2r} \quad \nabla \times \vec{\omega} = -\nabla(1/r)$$

- Locally  $\mathbb{R}^3 \times S^1$ :  $\kappa \sim \kappa + 2\pi$
- Isometry around circle
- Flat space at monopole core

# Puzzles in T-Duality to the NS5-Brane

- NS5 metric, torsion, dilaton derived from:

$$H(r, \theta) = \frac{1}{g^2} + \frac{1}{2r} \frac{\sinh r}{\cosh r - \cos \theta}$$

- Physics mismatch:  $\theta$  localized, throat at core

- Conjecture: “winding throat” for KK-mon

Gregory, Harvey, Moore  
hep-th/9708086

- Parallel case: *smear*d NS5-brane

- Localized by worldsheet instantons

Tong: hep-th/0204186

# Topological Term in a Gauged Linear Sigma Model

$$\mathcal{L}_D = \int d^4\theta \left[ \underbrace{\frac{1}{e^2} (-\Sigma^\dagger \Sigma + \Phi^\dagger \Phi)}_{\text{vector multiplet}} + \underbrace{Q^\dagger e^{2V} Q + \tilde{Q}^\dagger e^{-2V} \tilde{Q}}_{\text{charged hypermultiplet}} \right. \\ \left. + \underbrace{\frac{g^2}{2} (\Gamma + \Gamma^\dagger + \sqrt{2} V)^2 + \frac{1}{g^2} \Psi^\dagger \Psi}_{\text{linear hypermultiplet}} \right]$$

$$\mathcal{L}_F = \int d^2\theta \left( \sqrt{2} \tilde{Q} \Phi Q - \Phi \Psi \right) \quad \mathcal{L}_{\text{top.}} = \epsilon^{\mu\nu} \partial_\mu (\theta A_\nu)$$

- Low energy limit: NLSM for KK-monopole
- $\theta$  corresponds to KK-dyon coordinate

Sen, hep-th/9705212

# Worldsheet Instantons as GLSM Vortices

- No true vortex vacua in 2D
  - Constrained instantons: radius  $g \rightarrow 0$
- Abelian Higgs model at crit. coupling +  $\theta$  term
- Find leading behavior of  $\langle \psi^4 \rangle \Big|_{k\text{-instanton}}$
- Corrects  $R_{mnpq}$  in low energy NLSM
- Deduce corrections to metric and torsion:

$$H(r, \theta) = \frac{1}{g^2} + \frac{1}{2r} \frac{\sinh r}{\cosh r - \cos \theta}$$

# Localization in Winding Space

- Stringy KK-monopole differs from GR
- Localization and throat match NS5 physics
- Localized in “winding space” coordinate  $\theta$
- Non-geometric background
  - Describe using “doubled geometry”

Dabholkar, Hull  
hep-th/0512005

J. Harvey and S. Jensen: hep-th/0507204