#25 Emergence of magnetic monopoles for quark confinement due to violation of the non-Abelian Bianchi identity

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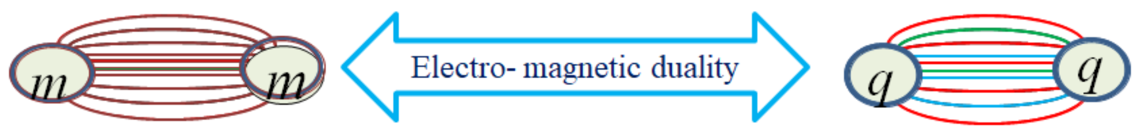
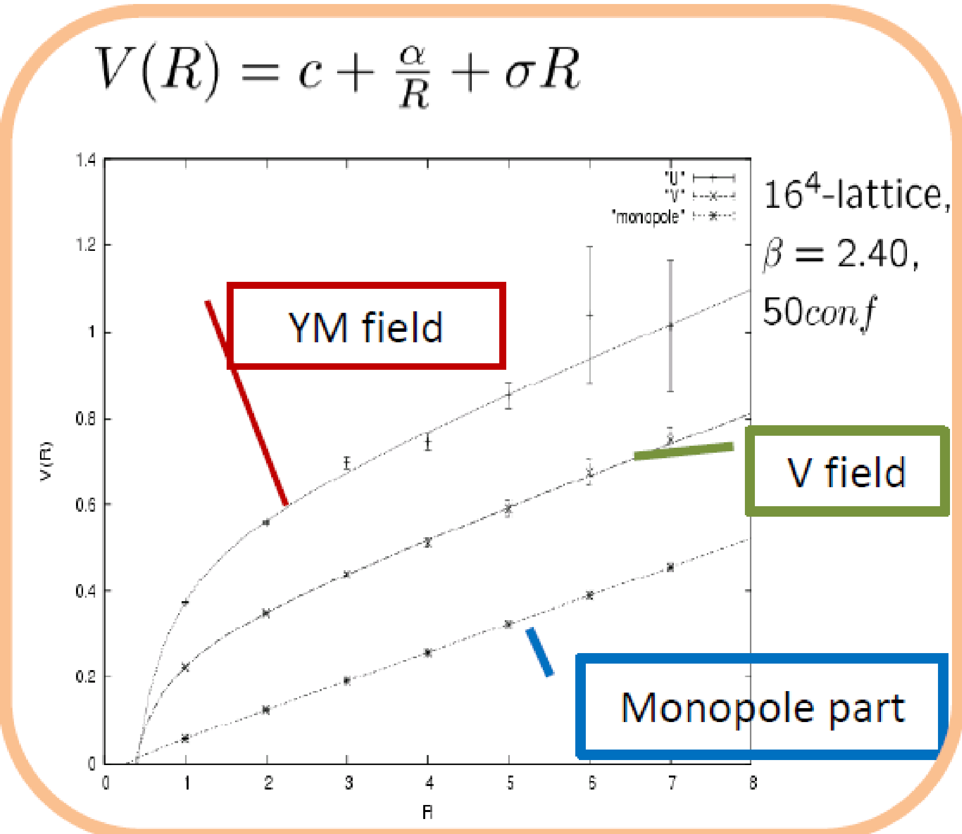
Quark Confinement

Dual superconductor picture is one of the most promising mechanism for quark confinement. In this picture, the magnetic monopole plays an important role.





The perfect magnetic-monopole dominance in the string tension, i.e., the string tension from Yang-Mills field is completely reproduce by one from the magnetic monopole.

Violation of Bianchi Identity vs emergence of magnetic monopole

$$\mathscr{J}^{\mu}_{\mathrm{m}}(x) = \sum_{k}^{N-1} K^{(k)}_{\mu}(x)\boldsymbol{n}^{(k)}(x)$$

$\mathscr{J}^{\mu}_{\mathrm{m}}(x)$ represents the magnetic current:

$$\mathcal{J}_m := \mathcal{D}[\mathcal{A}]\mathcal{F}[\mathcal{A}] = \mathscr{J}^{\mu}_{\mathrm{m}}\, dx^{\mu}\,, \qquad \mathscr{J}^{\mu}_{\mathrm{m}} := \mathscr{D}_{\nu}[\mathscr{A}]^{*}\mathscr{F}_{\mu\nu}[\mathscr{A}] = \varepsilon^{\mu\nu\alpha\beta}\mathscr{D}_{\nu}[\mathscr{A}]^{*}\mathscr{F}_{\alpha\beta}[\mathscr{A}]\,,$$

and $\mathscr{F}_{\mu\nu}[\mathscr{A}]$ represents the field strength for Yang-Mills field $\mathscr{A}$.
$\mathcal{K}^{(k)}$ represents the magnetic monopole:

$$\mathcal{K}^{(k)} = {}^{*}d\mathcal{F}^{(k)} = K^{(k)}_{\lambda}\, dx^{\lambda}\,,\; K^{(k)}_{\lambda} := \frac{1}{2}\epsilon^{\lambda\sigma\mu\nu}\partial_{\sigma}F^{(k)}_{\mu\nu}\,,\; F^{(k)}_{\mu\nu} = 2\mathrm{tr}\left(\mathscr{F}_{\mu\nu}[\mathscr{V}]\boldsymbol{n}^{(k)}(x)]\right)$$

and $\mathscr{F}_{\mu\nu}[\mathscr{V}]$ represents the field strength for the restricted field $\mathscr{A}$ obtained from the gauge-covariant field decomposition,$\mathscr{A}_{\mu} = \mathscr{V}_{\mu} + \mathscr{X}_{m}u$, and $\boldsymbol{n}^{(k)}(x)$ the color-direction field.

Current Conservation:	**Bianchi Identity**
$\mathscr{D}_{\mu}[\mathscr{A}]\mathscr{J}^{\mu}_{\mathrm{m}} = 0 \iff \partial_{\mu}K^{(k)}_{\mu} = 0$	$\mathscr{J}^{\mu}_{\mathrm{m}} = \mathscr{D}_{\nu}[\mathscr{A}]^{*}\mathscr{F}_{\mu\nu}[\mathscr{A}] = 0 \iff K^{(k)}_{\mu} = 0$

- The non-Abelian Bianchi identity is nothing but the motion of equation.
- The violation of Bianchi identity is due to quantum effect.

$\Longrightarrow$ Examine the phase transition between the Higgs phase and confinement phase.