QCD Kondo effect in quark matter with heavy flavor impurities

K. Hattori (RIKEN/BNL), K. Itakura (KEK), S. Ozaki (KEK), S. Yasui (Tokyo Institute of Technology)

Conclusion: Appearance of heavy quark impurities in a light quark matter gives rise to a drastic change of transport properties due to the QCD Kondo effect.


1. Introduction to “Kondo effect”

JUN KONDO [1930]

Progress of Theoretical Physics, Vol. 22, No. 1, July 1950

Resistance Minimum in Dilute Magnetic Alloys

<table>
<thead>
<tr>
<th>Key words for Kondo effect</th>
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<tbody>
<tr>
<td>Heavy impurity (mass → 0)</td>
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<tr>
<td>Fermi surface (particle-hole symmetry)</td>
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<tr>
<td>Loop effect</td>
</tr>
<tr>
<td>Non-Abelian int. (SU(n) symmetry)</td>
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2. Kondo effect in quark matter

“Kondo effect” in strong interaction

Medium | Nuclear Matter | Quark Matter |
<table>
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<tbody>
<tr>
<td>Impurity</td>
<td>D meson (ca)</td>
<td>Charm Quark</td>
</tr>
<tr>
<td>Non-Abelian</td>
<td>Tσ ∈ SU(2)loop</td>
<td>Tσ ∈ SU(3)color</td>
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What’s the effect of gluon-exchange?!

“Dynamical screening” in color magnetic gluon

Our Strategy

Renormalization group (RG) equation

1. Scattering amplitude at energy scale Λ

G(Λ, dΛ) = G(Λ) + Λ-dΛ G(Λ) + Λ-dΛ-Λ

Dynamical screening (energy-dependent mass)

Cf. Baym et al. (1990)

2. Properties of gluon-exchange

Gluon exchange (Non-Abelian int.)

Dynamical screening (Non-Abelian int.)


3. Renormalization group (RG) equation

\[ \frac{1 + \gamma}{2} \cdot \left( \frac{1}{\Lambda^2} \right) \sum \frac{1}{(1 + \gamma^2) \cdot \left( \frac{1}{\Lambda^2} \right)} \]

Dynamical screening by magnetic gluon

Enhancement of transport coefficients at low energy (temperature) scale:

\[ \Lambda \rightarrow \Lambda_0 (\text{Kondo scale}) \]

(CT interaction = Log(CT))

Kondo scale!!

(low energy scale for infrared divergence)