Gluons, Heavy and Light Quarks in the Instanton Liquid Model (ILM)

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Abstract

We are extending ILM to gluons, heavy quarks and heavy-light quarks systems.

In ILM $4N_c$ instanton collective coordinates = size $\rho \approx \bar{\rho}$, color orientation, position.

$\rho \approx 0.3\,\text{fm}$, inter-instanton distance $R \approx 1\,\text{fm}$, packing parameter $\lambda = \rho^4/R^4 \approx 0.01$.

- Instanton vs hadron sizes. $r_{J/\psi} = 0.25$ fm, $r_\Upsilon = 0.14$ fm, $r_N \sim 0.3 - 0.5$ fm.
  Small quark core size hadrons are insensitive to the confinement, ILM safely applicable.

- Light quarks in ILM. Dynamical quark mass $M(q)$.
  $M(0) \approx 360$ MeV $\sim \lambda^{1/2}\rho^{-1} \sim$ strength of light quark-instanton interaction.
  Successful reproducing of light hadrons physics with $O(m, 1/N_c, m/N_c)$ corrections.

- Gluons in ILM. Dynamical gluon mass $M_g(q)$.
  $M_g(0) \approx M(0) \sim \lambda^{1/2}\rho^{-1} \sim$ strength of gluon-instanton interaction.

- Heavy quarks in ILM. ILM contribution to heavy quark mass $\Delta M(q)$.
  $\Delta M(0) \approx 70$ MeV $\sim \lambda\rho^{-1} \sim$ strength of heavy quark-instanton interaction.
  Heavy quark-antiquark potential $V(r) =$ ILM modified one gluon exchange $V_{ILM,g}(r)$
  + direct instanton $V_{\rm dir}(r)$ + confinement $V_{\rm conf}(r)$ potentials.
  $V_{\rm cornell}(r) =$ one gluon exchange $V_g(r)$ + confinement $V_{\rm conf}(r)$ potentials.
  $V(r)$ vs $V_{\rm cornell}(r) \Rightarrow +5 \div 10\,\%$ correction for charmonium $(c\bar{c})$ ground state energy.

- Heavy+light quarks in ILM. $(c\bar{c})' \to (c\bar{c})\pi\pi$.
  Light quark factor $F_{\pi Q} \approx 0.6 F_\pi$.
  Heavy quark factor = dipole approximation$(1 + c\, r^2_{J/\psi}/\rho^2 + ...)$.
  $c\, r^2_{J/\psi}/\rho^2 \approx -0.372\, r^2_{J/\psi}/\rho^2 \approx -0.26$. Standard approach = dipole approximation.
  Request for ILM reconsideration of heavy quarkonium light hadrons emission processes
  and light-heavy quarks meson states.

ILM is a framework for uniform and consistent description of light and heavy quark physics.