Search for exotic hadrons with the PANDA detector

Jan Kisiel

Institute of Physics, University of Silesia
Katowice, Poland
(kisielj@us.edu.pl)

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Exotic hadrons:

• Glueballs \((gg, ggg, \ldots)\): made entirely out of glue

• Hybrids \((q\bar{q}g)\): \(q\bar{q}\) pairs with an excited gluon

• Molecules \((q\bar{q}q\bar{q})\): \(q\bar{q}\) pairs
Mesons and exotics to be studied with the PANDA detector

- **molecules** $qqq\bar{q}$
- **molecules** $c\bar{c}qq$
- **hybrids** $ssg u\bar{u}g$
- **hybrids** $c\bar{c}g$
- **glueballs**
- **light mesons** $\pi, \eta, \omega...$
- **charmonium**

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Exotic states mix with conventional $q\bar{q}$ states:

difficulties in observation

two possibilities

look for states with quantum numbers not accessible to conventional $q\bar{q}$ states.

reduce mixing

0 2000 4000 MeV/c$^2$
Search for glueballs

- glueballs bound gluon states
- quantum numbers:
  → exotic, $J^{PC}=2^{+-},1^{+-},0^{-+},...$
  → „normal”, mixing with qq states
- production cross section $\sim \mu b$
- $f_0(1500)$ – candidate
  → CB@LEAR
  → mixed with scalar qq states

Glueball mass spectrum (LQCD)

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Crystal Barrel $f_0(1500)$ data:

- high statistics, full solid angle, low threshold (~20 MeV) in EM calorimeter, kaons identification
- study of different decay channels (branching ratios)
- partial wave analysis (coupled channel analysis)

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Search for charmed hybrids \((c\bar{c}g)\):

\(\Pi\)-potential of excited gluon flux in addition to \(\Sigma\)-potential for one-gluon exchange may lead to bound states.

LQCD predictions for charmed hybrids:
- Mass: lowest state 4.2-4.5 GeV/c\(^2\)
- Quantum numbers: ground state \(J^{PC}=1^{+}\) (exotic), but many allowed
- Width: 5-50 MeV (narrow states)
Schematic view of PANDA detector on High Energy Storage Ring (HESR)