A new state of matter: Dibaryons

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Despite their long painful history dibaryon searches (where dibaryon means a baryon number *B=2* state independently on the internal structure: genuine six-quark state/baryonic-molecule) have recently received new interest, in particular by the recognition that there are more complex quark configurations than just the familiar $\bar{q}q$ and qqq systems. The "hidden color" aspect makes dibaryons a particularly interesting object in QCD.

A resonance like structure recently observed in double-pionic fusion to deuteron, at $M = 2.38\ GeV$ with $\Gamma = 70\ MeV$ and $I(J^p) = 0(3^+)$ meanwhile proved to be the so called “inevitable dibaryon” $d^*(2380)$. To investigate its structure we have measured its decay branches into the $d\pi^0\pi^0$, $d\pi^+\pi^-$, $pp\pi^-\pi^0$, $pn\pi^0\pi^0$ and pn channels.

The pn decay channel was measured by use of polarized deuterons in inverse kinematics. These new np analyzing power data exhibit a pronounced resonance effect in their energy dependence. The SAID partial-wave analysis with inclusion of these data reveals a pole in the complex plane of the coupled ${}^3D_3 - {}^3G_3$ partial waves at $(2380 \pm 10)MeV - i(40 \pm 5)MeV$ in accordance with the d* resonance hypothesis. An effect of the resonance in the ${}^3G_3$ partial wave might point out to a non-vanishing *D-wave* ΔΔ molecular component of the $d^*(2380)$ dibaryon.

$d^*(2380)$ dibaryon is robust enough to survive even in a nuclear surrounding, which may have interesting consequences for nuclear matter under extreme conditions. It has been shown that d^* resonance can explain some dilepton yield in heavy-ion collisions (”DLS Puzzle”). Dibaryons are bosons, hence not Pauli blocked and as such allow for higher densities of compressed nuclear matter. The effect of dibaryons on the equation of state for nuclear matter has been considered in various theoretical investigations.

Various theoretical calculations on d^* internal structure can be verified by future experiments in MAINZ and JLab. $d^*(2380)$ is unique multiquark system where the interplay between six-quark and molecular baryon-baryon components can be actually measured. Further investigations on d^* dibaryon SU(3) multiplet companions as well as the mirror partners are expected to be done in near future by COSY, JLab, J-PARC and PANDA facilities.