Abstract

The goal of the GlueX experiment is to provide critical data needed to address one of the outstanding and fundamental challenges in physics – the quantitative understanding of the confinement of quarks and gluons in quantum chromodynamics (QCD). Confinement is a unique property of QCD and understanding confinement requires an understanding of the soft gluonic field responsible for binding quarks in hadrons. Hybrid mesons, and in particular exotic hybrid mesons, provide the ideal laboratory for testing QCD in the confinement regime since these mesons explicitly manifest the gluonic degrees of freedom. Photoproduction is expected to be particularly effective in producing exotic hybrids but there is little data on the photoproduction of light mesons. GlueX will use the coherent bremsstrahlung technique to produce a linearly polarized photon beam. A solenoid-based hermetic detector will be used to collect data on meson production and decays with statistics after the first full year of running that will exceed the current photoproduction data in hand by several orders of magnitude. These data will also be used to study the spectrum of conventional mesons, including the poorly understood excited vector mesons. In order to reach the ideal photon energy of 9 GeV for this mapping of the exotic spectrum, 12 GeV electrons are required.

Quantum chromodynamics (QCD) provides a clear description of the strong interaction of quarks and gluons at high energy; however, obtaining quantitative predictions from QCD at low energy remains challenging. Interestingly, it is at these low energies that we observe the most obvious physical manifestation of QCD, the spectrum of particles that make up the universe we live in, baryons and mesons. While models do provide predictions for this spectrum, to obtain this spectrum as a solution to QCD is currently only possible using numerical techniques to calculate it, lattice QCD.

The observation, nearly five decades ago, that mesons are grouped in nonets, each characterized by unique values of J^{PC}–spin (J), parity (P) and charge conjugation (C) quantum numbers—led to the development of the quark model. Within this picture, mesons are bound states of a quark (q) and antiquark ($\bar{q}$). The three light- quark flavors (up, down and strange) suffice to explain the spectroscopy of most but not all of the charmless mesons lighter than the $c\bar{c}$ ground state (≈ 3 GeV/c^2).

Our understanding of how quarks form mesons has evolved within QCD, and we now expect a richer spectrum of mesons that takes into account not only the quark degrees of freedom but also the gluonic degrees of freedom. Excitations of the gluonic field binding the quarks can also give rise to so-called hybrid mesons that can be viewed as bound states of a quark, antiquark and valence gluon ($q\bar{q}g$).

The GlueX detector has been designed to observe these exotic-quantum-number hybrid states. A program in spectroscopy, supported by a sophisticated amplitude analysis, will map out the spectrum of the exotic-quantum-number states. At the same time, the spectrum of the normal $q\bar{q}$ mesons will be studied. Detailed comparisons of our experimental results to theoretical predictions on the excitations of the gluonic field in mesonic systems will lead to a more detailed understanding of the role of glue in the confinement of quarks inside hadronic matter.