W16a Understanding Optical and Near-Infrared Variability during the Periastron Passage of the Gamma-Ray Binary PSR B1259−63: Insights from 3D Simulations

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Gamma-ray binaries, characterized by their radiative output peaking above 1 MeV, remain enigmatic systems with only nine known examples, comprising a massive star and a compact object. Among the known gamma-ray binaries, five exhibit an O star companion, while four are associated with Be stars – massive stars surrounded by circumstellar disks. Unraveling the complex physics governing interactions in gamma-ray binaries, especially those involving Be stars, poses a significant challenge.

This presentation focuses on the optical and near-infrared variability exhibited by PSR B1259−63. This unique system consists of a radio pulsar with a relativistic pulsar wind orbiting a Be star in an extremely eccentric ($e = 0.87$) and wide ($P_{\rm orb} = 3.4$ yr) orbit. Despite previous investigations, the emission mechanisms at play in this system remain incompletely understood.

We employ 3D SPH simulations of PSR B1259−63 to shed light on the intricate interaction between the pulsar's relativistic wind, the stellar wind, and the circumstellar disk surrounding the Be star. We then develop an emission model utilizing the simulation data. By comparing the simulated variability with observational data, we gain valuable insights into the origins of the observed variability. Specifically, we find that the pronounced increase in EW(Hα) around periastron primarily stems from tidal interactions, while the pulsar wind also contributes significantly to this variability.