Gamma-ray and Neutrino Emission in X-ray Binaries: The Role of Jet Cooling, Photo-absorption, and Black Hole Spin

Dr. Theodora Papavasileiou

Department of Physics, University of Ioannina, Greece
Email: <theodora836@gmail.com>

Abstract

In recent decades, many studies have focused on fitting the broadband emission from X-ray binary systems (i.e., XRBs) covering the energy range from radio to high-energy gamma-rays and neutrinos. Those fits provide new insights into the accretion process, the mechanisms associated with jet acceleration and collimation, the spectral state transitions, and the dynamics between the disk and the corona. Reproducing the spectrum from accretion disks offers information about the black hole and its formation and evolution process, including the mass and spin. Although many XRBs have been observed in X-ray and radio frequencies, very high-energy (VHE) gamma-ray emissions and neutrinos were rarely or never recorded from any similar source. We aim to explain the lack of relevant observations by employing a lepto-hadronic jet model and deriving the associated spectra from 10^{-4} eV to 10^{15} eV. More specifically, the investigation includes the implications of intense jet-particle cooling and photo-absorption effects following jet-photons annihilation with the emission from the accretion disk and the stellar companion.

Our results reveal minimal prospects of neutrino detection from all studied XRBs, except Cygnus X-1 in the 0.1-1 TeV range. Likewise, the jet gamma-ray fluxes are heavily absorbed during their path towards the observer. Absorption is more intense in the 10 GeV $< E_\gamma <$ 20 TeV range, coinciding with the operation range of most gamma-ray telescopes. Concerning the accretion disk, we introduce a novel, straightforward approach to obtaining relativistic-equivalent disk spectra. This is accomplished by adopting the standard disk model with a spin-dependent temperature profile and an inner boundary determined by the Kerr metric and the viewing angle. The boundary transition is found to belong in the $R_{in}/R_{ISCO} = 0.2 - 1.0$ range when the viewing angle exceeds 60°, while $R_{in}/R_{ISCO} = 1.0 - 2.0$ for an edge-on view of the disk.