Modeling TeV gamma-rays from LS 5039: An active OB star at the extreme

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Perhaps the most extreme examples of "Active OB stars" are the subset of high-mass X-ray binaries -- consisting of an OB star plus compact companion -- that have recently been observed by Fermi and ground-based Cerenkov telescopes like HESS to be sources of very high energy (VHE; up to 30 TeV) gamma-rays. This paper focuses on the prominent gamma-ray source, LS5039, which consists of a massive O6.5V star in a 3.9-day-period, mildly elliptical (e = 0.24) orbit with its companion, assumed here to be a black-hole or unmagnetized neutron star. Using 3-D SPH simulations of the Bondi-Hoyle accretion of the O-star wind onto the companion, we find that the orbital phase variation of the accretion follows very closely the simple Bondi-Hoyle-Lyttleton (BHL) rate for the local radius and wind speed. Moreover, a simple model, wherein intrinsic emission of gamma-rays is assumed to track this accretion rate, reproduces quite well Fermi observations of the phase variation of gamma-rays in the energy range 0.1-10 GeV. However for the VHE (0.1-30 TeV) radiation observed by the HESS Cerenkov telescope, it is important to account also for photon-photon interactions between the gamma-rays and the stellar optical/UV radiation, which effectively attenuates much of the strong emission near periastron. When this is included, we find that this simple BHL accretion model also quite naturally fits the HESS light curve, thus making it a strong alternative to the pulsar-wind-shock models commonly invoked to explain such VHE gamma-ray emission in massive-star binaries.

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