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Jet modeling: from X-ray binaries to dark matter nature

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Recent advancements in gamma-ray observations and theoretical modeling are transforming our understanding of relativistic jets across scales, from black hole X-ray binaries (BHXBs) to active galactic nuclei (AGN). Jets are efficient cosmic ray (CR) accelerators to PeV energies, contributing to the diffuse gamma-ray and neutrino fluxes. In BHXBs, jets persist even during quiescence, like the case of A0620−00, suggesting their contribution to Galactic PeVatrons has been underestimated, particularly after the recent results of LHAASO on TeV emission from BHXBs. Additionally, AGN jets reveal complex interactions between CR and their environments, producing multiwavelength (MW) emission through leptonic and hadronic processes. In this talk, I will present a unified framework for modeling jet systems using an extended version of the BHJet model. By advancing its computational capabilities, this model bridges the gap between small-scale BHXB jets and large-scale AGN jets, incorporating the effects of interactions with light dark matter. Applying BHJet to A0620−00 highlights the potential cumulative gamma-ray and X-ray contributions of the BHXB population, with implications for their detectability with future observatories like CTA. For AGN, BHJet captures the steady-state MW emission accounting for the elastic scattering between CRs and light DM particles. This analysis not only deepens our understanding of jet physics but also offers insights into the potential dark matter signatures in jet environments, advancing the study of astrophysical PeVatrons and their role in fundamental physics.

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