Z207a Modeling Cosmic-Ray Transport and Nonthermal Emission in the Jets of SS 433

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The X-ray binary system SS 433 launches mildly relativistic jets that extend over several tens of parsecs. The nonthermal emission detected from the jets is best explained by multi-TeV electrons producing X-rays and TeV gamma rays through synchrotron and inverse-Compton processes, respectively. The recent LHAASO detection of ultra-high-energy (>100 TeV) gamma-ray emission further establishes SS 433 as a potential PeVatron. A proper understanding of the conditions required for accelerating particles to PeV energies calls for detailed modeling of the full X-ray and gamma-ray data set.

We present a multi-zone cosmic-ray transport framework that allows us to model the nonthermal emission and reproduce a wide range of observational results, including the energy-dependent morphology of the emission regions in both the X-ray and gamma-ray bands. While we use a stationary jet model, the jet parameters adopted in our study are consistent with the measured proper motions of the X-ray knots. We discuss the theoretical implications of our findings, in particular the required acceleration efficiency and its relation to the Bohm limit.