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Recent Developments in Plasma Astrophysics

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Most of the baryonic matter in the universe exists in an ionized form within stars and the intergalactic medium. For many purposes, it is adequate to treat it as a fluid endowed with a bulk velocity, density, pressure etc despite the fact it is is often out of thermodynamic equilibrium. Understanding when this is justified and explaining a growing list of observed phenomena that depend upon collisionless, collective effects is the domain of plasma astrophysics. The scales exhibited by cosmic plasma phenomena range from those associated with terrestrial auroras to giant clusters of galaxies. There are many fundamental plasma processes that operate in essentially similar ways within these varied environments including the transport of momentum, heat and cosmic rays, the stretching and reconnection of magnetic field lines and the formation of collisionless shocks. Understanding these processes is a pre-requisite to accounting for such diverse observations as the acceleration of $\sim$PeV protons in nearby supernova remnants and $\sim$ZeV protons in extragalactic sources, the formation of relativistic jets and X-ray emission by accretion disks and the circumgalactic medium. Recent progress derives from remote and and in situ observations as well as large scale numerical simulations.