Abstract

Stars can lose mass in various ways, significantly shaping their evolution and driving diverse astrophysical phenomena. In this thesis, we develop models of stellar mass loss in two distinct settings. First, we propose a theory of mass transfer in binary stars, treating the Roche potential as a converging nozzle that channels material through the inner Lagrange point. Including radiative effects, our model shows that radiation enhances mass transfer from underfilling, radiation-dominated envelopes. Additionally, super-Eddington, convectively inefficient layers can drive high rates even before Roche-lobe overflow, potentially explaining outbursts resembling those of Luminous Blue Variables. Second, we introduce a model of mass ejection in magnetar giant flares (GFs), energetic bursts from highly magnetized neutron stars. Motivated by the radio afterglow of the 2004 GF from SGR 1806−20, we model how sudden magnetic dissipation forms a high-pressure shell that shock-heats and ejects part of the crust. Analytical estimates and relativistic hydrodynamic simulations show that the ejecta meet conditions for heavy-element rapid neutron-capture (r) process nucleosynthesis. This suggests that GFs are a novel, star-formation-tracing r-process site, recently corroborated by gamma-ray modeling and observational comparison by A. Patel et al. We also predict fast optical/UV transients, "nova brevis," peaking within minutes of the flare.