N34a Convection driven internal gravity wave transport in a 3D core-collapse progenitor

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Buoyancy supported internal gravity waves (IGWs) are inevitably excited by convective burning regions in massive stars. During violent oxygen (O) shell burning energy transported by waves can (1) source increased temperatures near the stellar surface, where enhanced luminosity in the progenitor is expected during the final year before explosion. Enhanced luminosity has been observed with high cadence by ZTF and ATLAS during the final year for both type II (SN2020tlf: Jacobson-Galán+2022) and also Ib (SN2023fyq: Brennan+2024, Dong+2024). Sufficiently strong wave transport is also expected to (2) eject $\sim 0.1 M_{\odot}$ during O burning (Quataert and Shiode 2012). Binary stellar evolution and winds can explain mass loss rates up to around $10^{-4} M_{\odot}$/year, but there are recent extreme cases of mass loss such as $10^{-3} M_{\odot}$/year (SN Ic 2020oi: Maeda+2021), and $\sim 0.01 - 1 M_{\odot}$/year (SN2023ixf: e.g. Hiramatsu+2024) during the final year. IGWs may explain large mass loss of $10^{-2} - 0.1 M_{\odot}$/year (2), as well as enhanced pre-supernova luminosities (1). However, 1D stellar evolution simulations which model wave transport do not reproduce the observed enhanced pre-supernova luminosities, or most extreme mass loss. 3D simulations suggest that convective regions which source IGWs have latitudinal differential rotation. According to analytic theory, IGW transport to the stellar surface depends sensitively on local rotation, however 1D simulations rely on rigid rotation of convective regions. Using a 3D hydrodynamics simulation of a Wolf Rayet star during O shell burning, we quantify how differential rotation enhances the predicted wave energy which can be deposited near the surface, ejecting mass.