Contribution ID: **111** Type: **Poster**

321D modelling of the interplay between turbulence and nuclear reactions in massive stars

Monday 16 September 2024 20:15 (20 minutes)

Given the key role massive stars and core-collapse supernovae play in the Universe, developing theoretical models of massive stars and their final collapse is critical. Massive stars are complex 3D objects involving a wide range of interesting physical processes like convection. Stellar models would thus ideally be three-dimensional (3D) (magneto-)hydrodynamic models that include all the relevant physics. These 3D hydrodynamic models, however, must use time steps that are many orders of magnitude shorter than the lifetime of stars. This explains why most stellar evolution models are limited to 1D (e.g. GENEC, MESA codes), equivalent to limiting models to spherical symmetry (or averages). These 1D models have wide ranging applications in astrophysics due to the importance of massive stars. The predictive power of 1D models, however, is crippled by 1D prescriptions of 3D phenomena containing free parameters that need to be calibrated using observations. In this talk, I will present our recent efforts to study convection and its interplay with nuclear reactions in 3D. I will in particular focus on cases where deviations from spherical symmetry are expected (e.g. shell mergers) and discuss how these 3D simulations can be used to improve 1D models.

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Session Classification: Poster Session