HEDLA 2022
13th International Conference on High Energy Density Laboratory Astrophysics
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The Progenitor-Supernova-Remnant connection: recent progresses and future prospects

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The remnants of core-collapse supernovae (ccSN) are diffuse extended sources with a complex morphology and a highly non-uniform spatial distribution of ejecta. In young (< 5000 years) remnants, part of their features reflect the inner mechanisms of the SN engine, in particular, those determining the nucleosynthetic yields and the large-scale asymmetries left from the earliest phases of the SN explosion. Other features originate from the structure of the progenitor star at collapse and from the effects of remnant interaction with the circumstellar medium (CSM) resulted from the mass-loss history of the progenitors. Hence, investigating the link between young supernova remnants (SNRs), parent SNe and progenitor massive stars can be essential: 1) to probe the physics of SN engines by providing insight into the asymmetries that occurred during the SN explosion, and 2) to investigate the endpoint in massive stars evolution and the still uncertain physical mechanisms that drive their mass-loss. Nowadays, our ability to study the progenitor-SN-SNR connection has been greatly improved thanks to three-dimensional magnetohydrodynamic models that describe the longterm evolution from the progenitor star, to the SN and to the SNR as well as to observational data of growing quality and quantity across the electromagnetic spectrum that allow to constrain the models. In this talk, I will review recent progresses in modeling young to middle-aged SNRs, focusing on investigations aimed at linking the observed physical and chemical properties of SNRs to their parent SN explosions and to progenitor stars. I will discuss the role of post-explosion anisotropies vs inhomogeneous environment in shaping SNRs, highlighting the importance of disentangling the two effects in the interpretation of SNR observations. Finally, I will comment on the future prospects in view of upcoming astrophysical instruments and telescopes.