Multi-messenger Astronomy and Core-Collapse Supernovae

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SN 1987A – A Plethura of Firsts

- Sanduleak -69 202 (Blue Supergiant!)
- Neutrinos – proof that some supernovae arise from stellar collapse
- Gamma-Rays probed the production of $^{56}$Ni (It is mixed out… solving this led to the current engine paradigm)
Multi-messenger Signals in the 2020s

New Discoveries

• Expanding survey and follow-up telescopes observe more progenitors and new types of transients

Probes of the Engine

• Neutrinos – Diffuse detection, detailed signals in the MW, trace detections further out
• GWs – turbulence in MW, rotation rates further out
Multi-messenger Signals in the 2020s

Nucleosynthetic Yields:

• Nebular Spectra:
• Gamma-rays probe radioactive isotopes produced in the star and the engine
• Dust Grains: new instruments are allowing measurements of multiple isotopes for a single micron-sized grains.
• Supernova Remnants (shocked abundances)
Different Messengers and Wavelengths Probe Different Parts of the Supernova

Stellar Mixing Probed by Yields

Engine: Probed by GWs, ’s and Yields

Remnant: CRs and EM probe shocks, yields and and SN

Light-Curve: EM probe star, CSM and SN

10-1000km

1000-10^6km

10^7-10^{11}km

>10^{12}km