

Importance of Type Ia in Cosmology



Type Ia supernova

- We can estimate distances to Type Ia supernovae fairly accurately.
 - Because they all explode at the same mass ($\sim 1.44M_{\text{solar}}$), their luminosity is roughly the same for all Type Ia.
 - We measure their brightness.
 - We know their luminosity.
 - Luminosity-brightness relation gives distances.
- **Distance-redshift relation** is one of the fundamental cosmological probes.
- How do we find Type Ia?
 - No hydrogen line should be seen for Type Ia

What about Type II?

- $M > 2M_{\text{solar}}$
 - More mass, more gravity \rightarrow More pressure, higher temperature
 - Hydrogen and helium are much more rapidly consumed (\sim a few 100,000 years or less vs billions of years)
 - Then, **carbon does fuse!!** (E.g., $^{12}\text{C} + ^4\text{He} \rightarrow ^{16}\text{O}$)
 - Heavier elements are also burned one after another.
 - E.g., $^{16}\text{O} + ^4\text{He} \rightarrow ^{20}\text{Ne}$, $^{20}\text{Ne} + ^4\text{He} \rightarrow ^{24}\text{Mg}$
 - E.g., $^{12}\text{C} + ^{16}\text{O} \rightarrow ^{28}\text{Si}$, $^{28}\text{Si} + ^{28}\text{Si} \rightarrow ^{56}\text{Fe}$
 - **Iron (^{56}Fe) is the terminal:** no more energy gain by fusion.
 - The core keeps shrinking... Gravitational force is not balanced by thermal pressure... Where would the gravitational energy go...
 - **Type II Supernova!!** (Hydrogen lines should be seen.)
- Intermediate mass stars ($8M_{\text{solar}} > M > 2M_{\text{solar}}$)
 - The core becomes a *neutron star* ($\sim 10\text{km}$ across; rapidly rotating)
- Very high mass stars ($M > 8M_{\text{solar}}$)
 - The core collapses into a *black hole*

Life and Low- and High-mass Stars

- Low-mass stars are necessary for life because...
 - Planets can form around low mass stars
 - Stars live long enough (\sim billions of years) for complex form of life to emerge
- High-mass stars are necessary for life because...
 - Low-mass stars alone cannot produce important heavy elements such as carbon, oxygen, nitrogen, etc.
 - High-mass stars can create heavy elements by fusion, and eject the created elements into space by Type II supernova explosion.
- Life is not possible without both!