

Supernovae and cosmology

On the Death of Stars
and
Standard Candles

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Supernovae



Types of Supernovae

- Type I
 - Ia (no hydrogen but strong silicon lines in spectrum)
 - Ib (non ionized helium lines)
 - Ic (no silicon and no hydrogen)
 - Ipec (strange lines in spectrum)
 - Type II
 - II-P (light intensity stays constant for some time)
 - II-L (linear decrease in light intensity)
 - IIpec (strange lines in spectrum)
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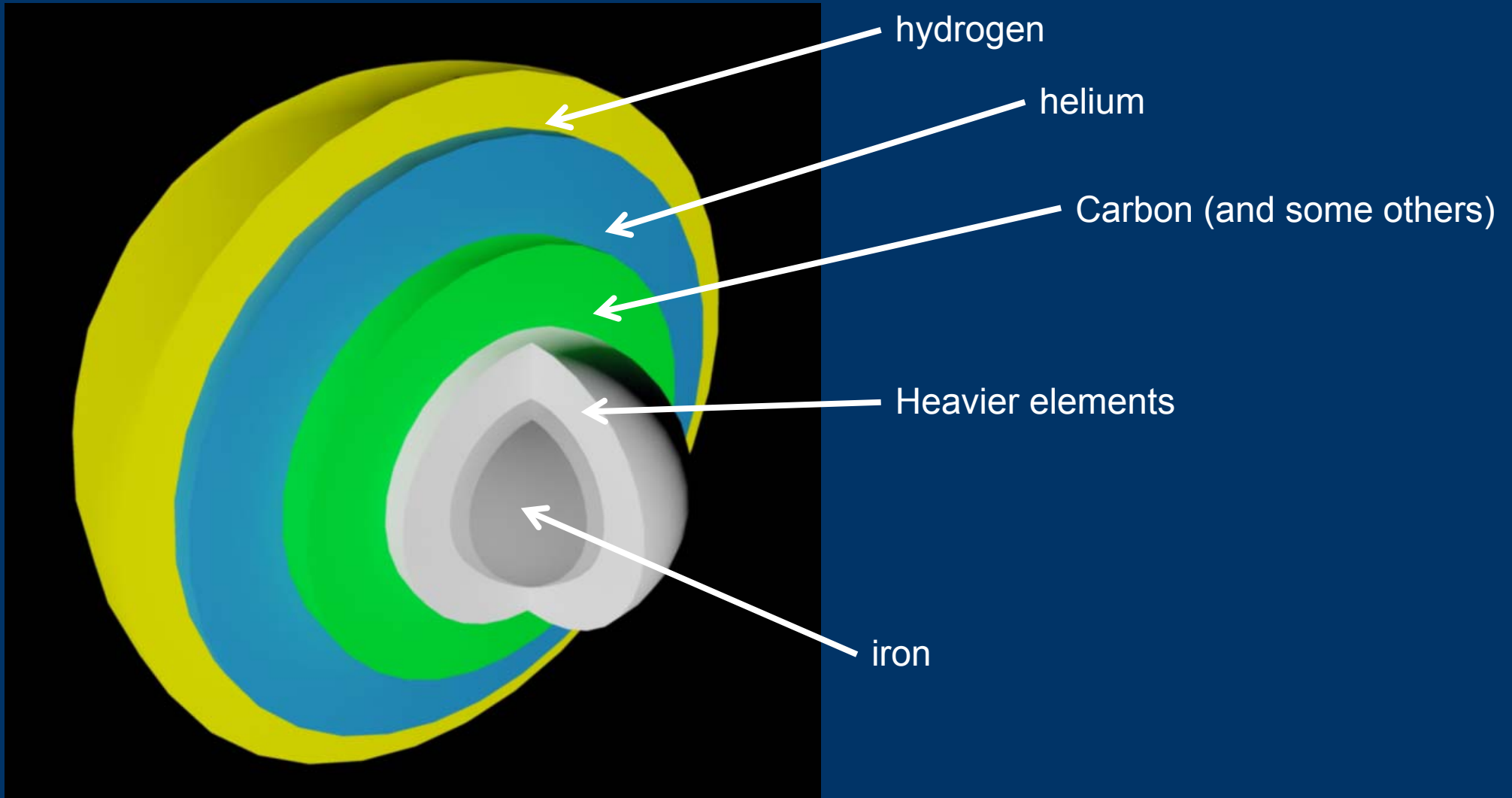
Type II supernovae

- Very large stars
 - High degenerate pressure in core
 - Core made of iron
 - Made up of shells
 - Every shell inward contains heavier atoms

Moving towards a type II supernova

1. fusing hydrogen into helium in the core (main sequence)
 2. fusing hydrogen into helium in shells around the core (start of red giant phase)
 3. fusing helium into heavier elements in the core
 4. fusing helium into heavier elements in the shell
 5. fusing the core into iron -> electron degeneracy pressure
 6. core collapse
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Moving towards a type II supernova



Type II supernovae

- Core collapse
 - Metal core too heavy for electron degeneracy
 - Core collapses

Potential energy

Given M the mass of the core:

- Gravitational potential energy for a sphere is given by:

$$5GM/3R$$

- The force is therefore

$$-5GM/3(R^2)$$



Potential energy

- Closer to the core, the gravity increases.
- On the surface of the core gravity is strongest
- Gravity increases on surface of the core as it shrinks



Core collapse

- Core collapse
 - Metal core too heavy for electron degeneracy
 - Weight more than Chandrasekar limit
 - Core collapses
- Gravity increases
 - Pressure increases on gas surrounding core
 - Potential energy is released as heat
- Heat and Pressure
 - Heat and pressure start higher mass nuclear fusion in shell surrounding the core

Post core collapse

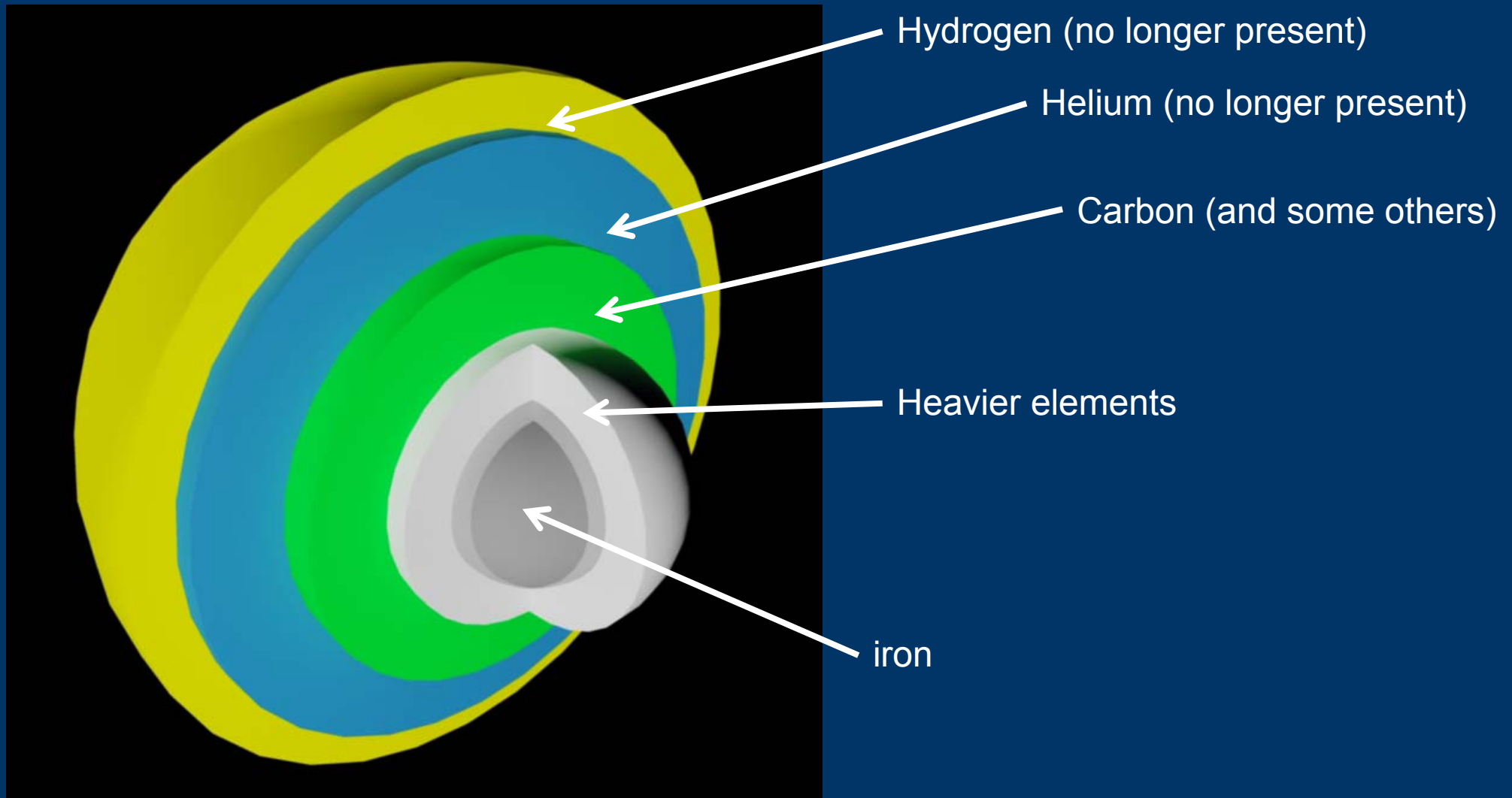
- Temperature keeps increasing around the core
 - More temperature dependent fusion kicks in
 - Pressure in the inside of the star keeps increasing
- Pressure on the inside blows away the rest of the star



Type Ib and Ic supernovae

- Supernovae from smaller object
 - Object smaller than sun
 - Envelope blown away by stellar wind or absorbed by companion
 - Possible progenitor to Ib: Wolf-Rayet stars
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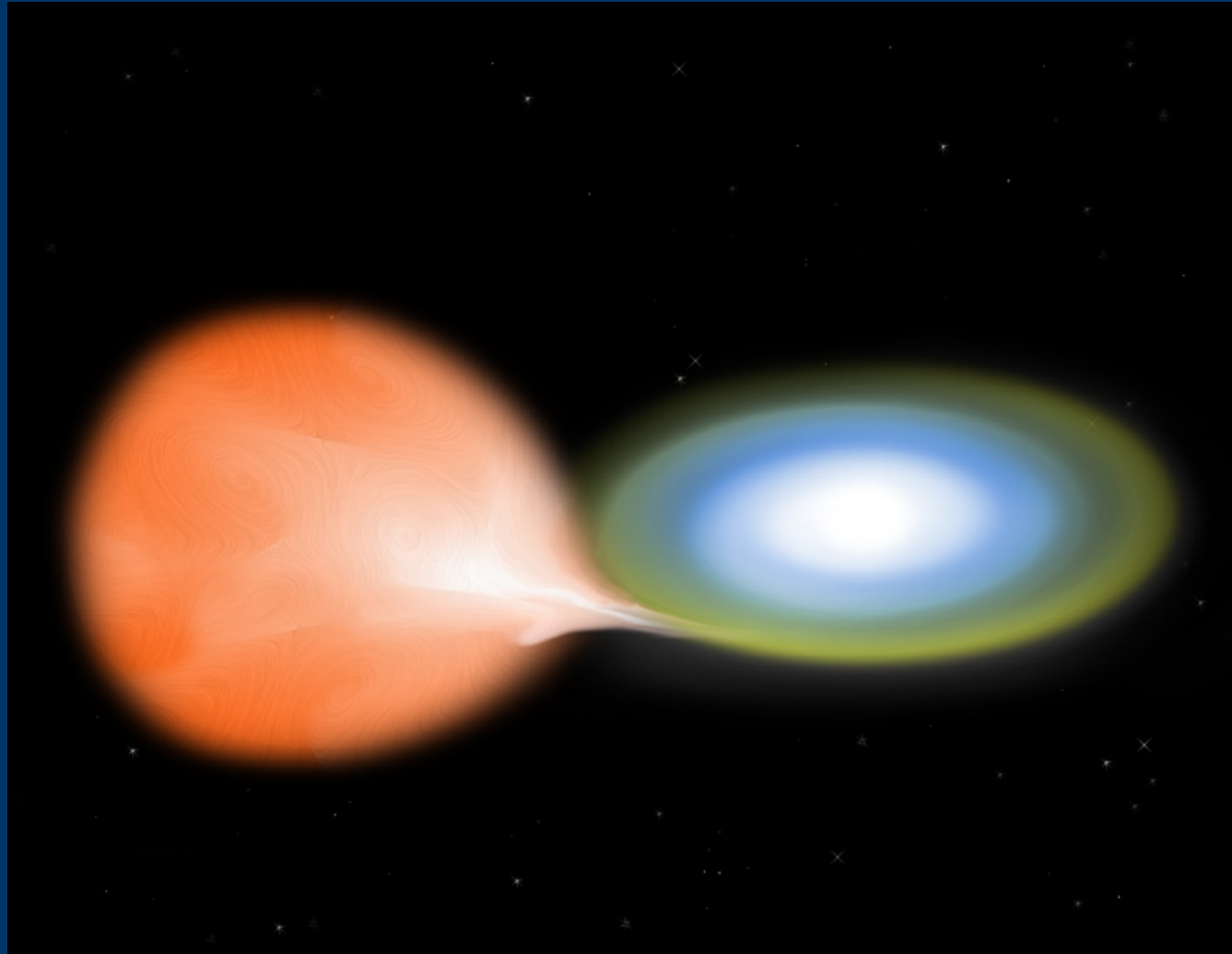
Moving towards a type Ib/c supernova



Type Ia supernova

- Caused by a white dwarf instead of a massive star.
- White dwarf sucks in matter from a star near it

Type Ia supernovae



Moving towards a type Ia supernova

- White dwarf sucks matter from accompanying star
- Matter fuses in bursts (novae)
- Core becomes more heavy

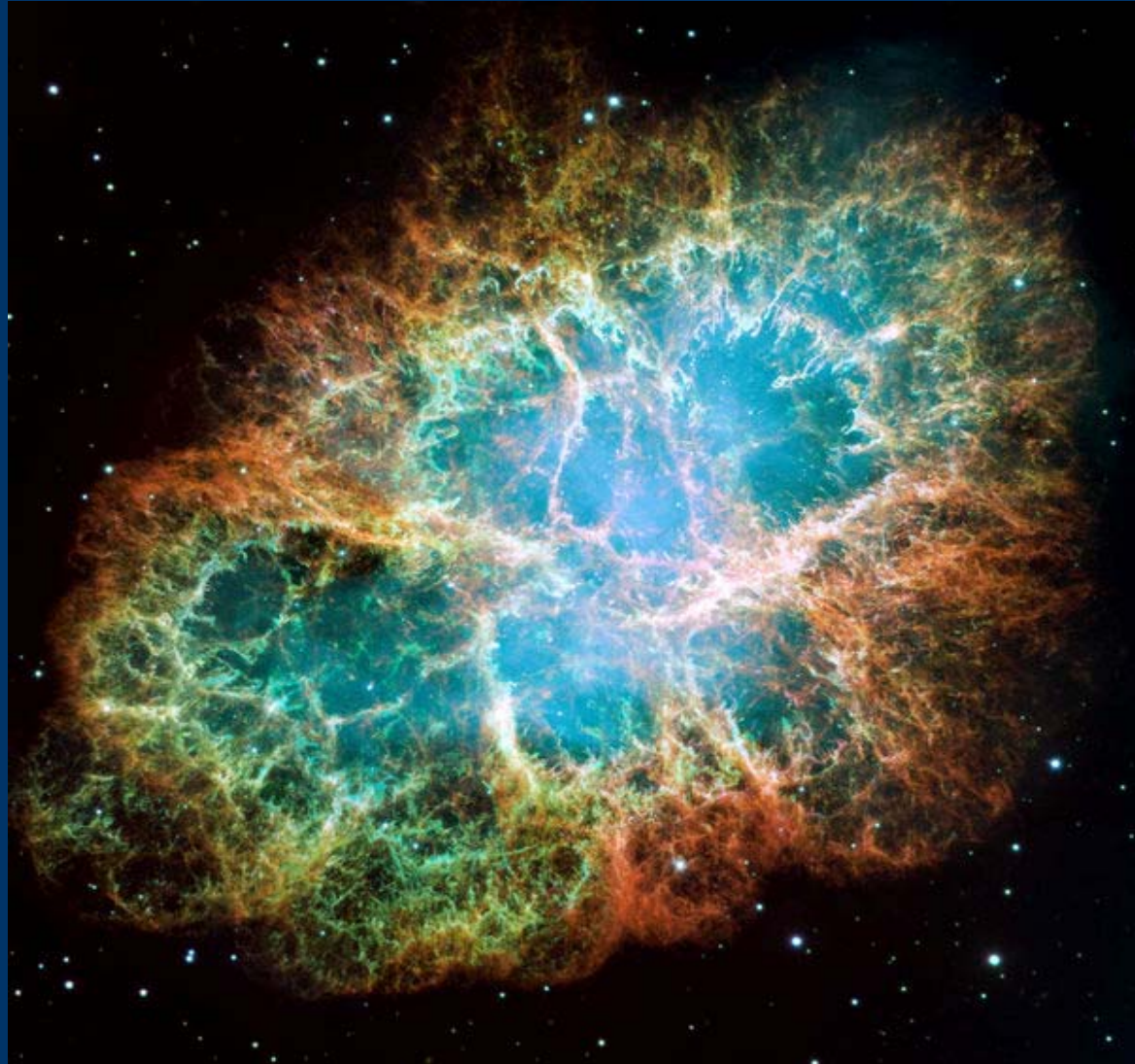


Moving towards a type Ia supernova

- Core more heavy than Chandrasekar limit
- Core collapses
- Explosion formes similar to type II supernova



After supernova



Cosmology



Application

- Standard candle
 - Type Ia supernova
 - Cepheids
 - nebula luminosity function

Problems in Cosmology

- What is the future of the universe?
 - Distances



Alexander Friedman

- 3 possibilities for the future of the universe
 - The universe is keeps expanding
 - The universe will collapse
 - The universe will be almost static

Expansion

- The average distances between galaxies is increasing
 - Further galaxies move faster away from us on average.
 - What we do not know is the exact distance from us
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Expansion

- The speed galaxies move away depends on the Hubble constant and on the distance of the galaxies.
 - Hubble constant is ± 70 (km/s)/Mpc
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Standard candles



Types of standard candles

- Type Ia supernovae (rare)
- Cepheids (needs close proximity)
- Planetary Nebulae (needs close proximity)

Only supernovae are valid for great distances!

Type Ia supernovae

- Intensity differs among type Ia supernovae
- Change of luminosity depends on intensity

- Find the distance from intensity.
- Relatively precise measurement



The hunt for supernovae

- Several telescopes scanning the sky
 - Revisit same position and measure difference in amplitude
 - Two groups
 - Supernova Cosmology (Berkeley lab)
 - High-Z supernova search
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Results

- The expansion of the universe is accelerating



Quality

- How good is our guess at the light intensity?



How to test quality of result

- Compare to other standard candles
 - Nearby galaxies with type Ia supernova's
 - Look at nebula luminosity function for comparison
 - Results on distance within 1% equal.
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Concluding

- Supernovae are dying stars or exploding white dwarfs
- The type Ia supernovae are valid for determining big distances
- The measurements are quite precise and have unexpected results.