Supernovae

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Content

What are supernovae

Why are they so important

Classification

Type 1A + applications

Type 2 + applications

Instabilities and turbulence

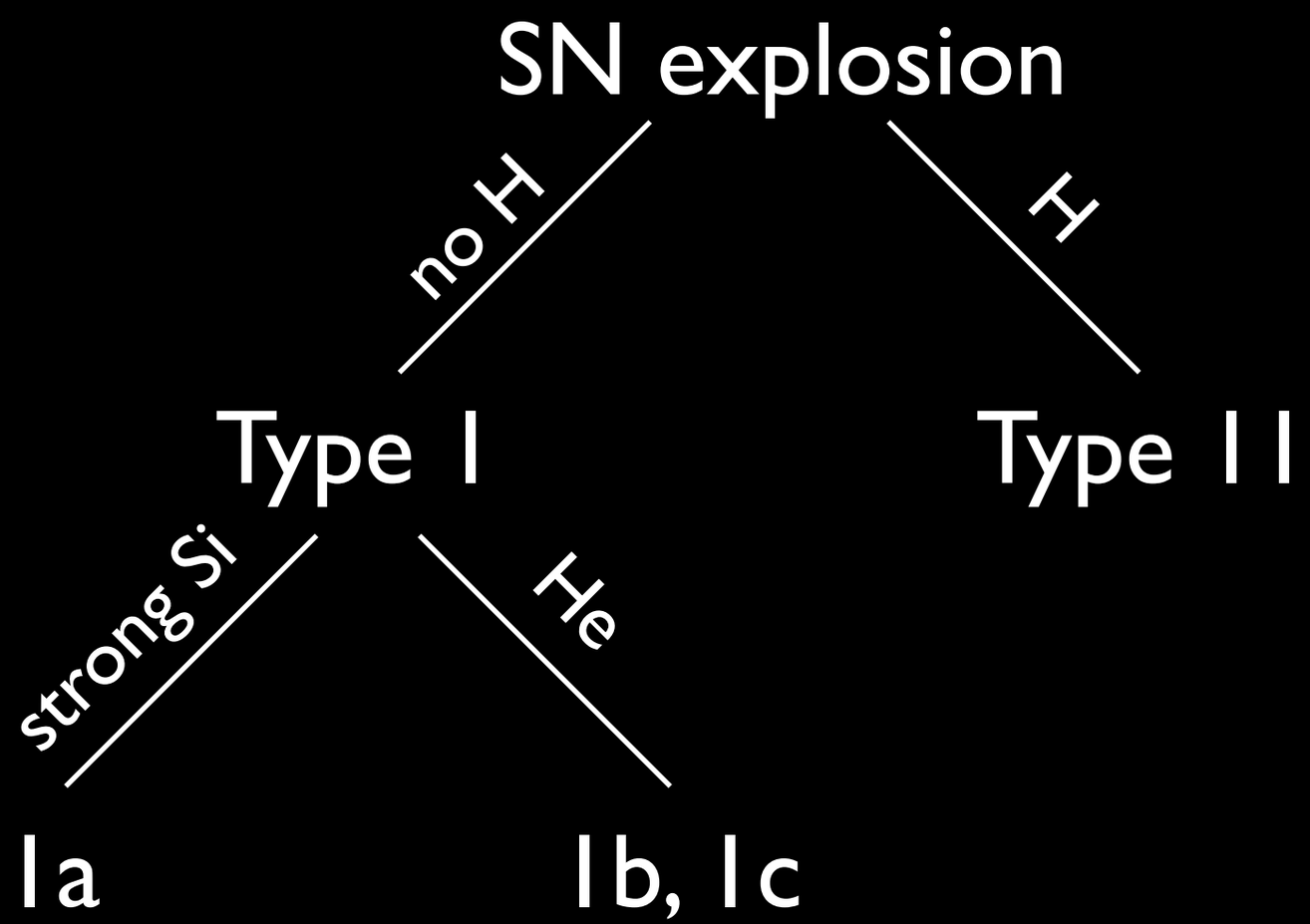
What are supernovae?

Unlike the name proposes
SN are the violent death of a Star

Why are SN important?

important applications (despite pretty pictures):
production of heavy elements
distance measurements

Classification



SN Ia explosion

Wave of thermonuclear fusion through white dwarf

Synthesizing elements (Ni, Co, Fe, Si, S, Ca, Mg, O)

The explosion is not what we see as the supernova

SN Ia Light-curve

Radioactive decay of

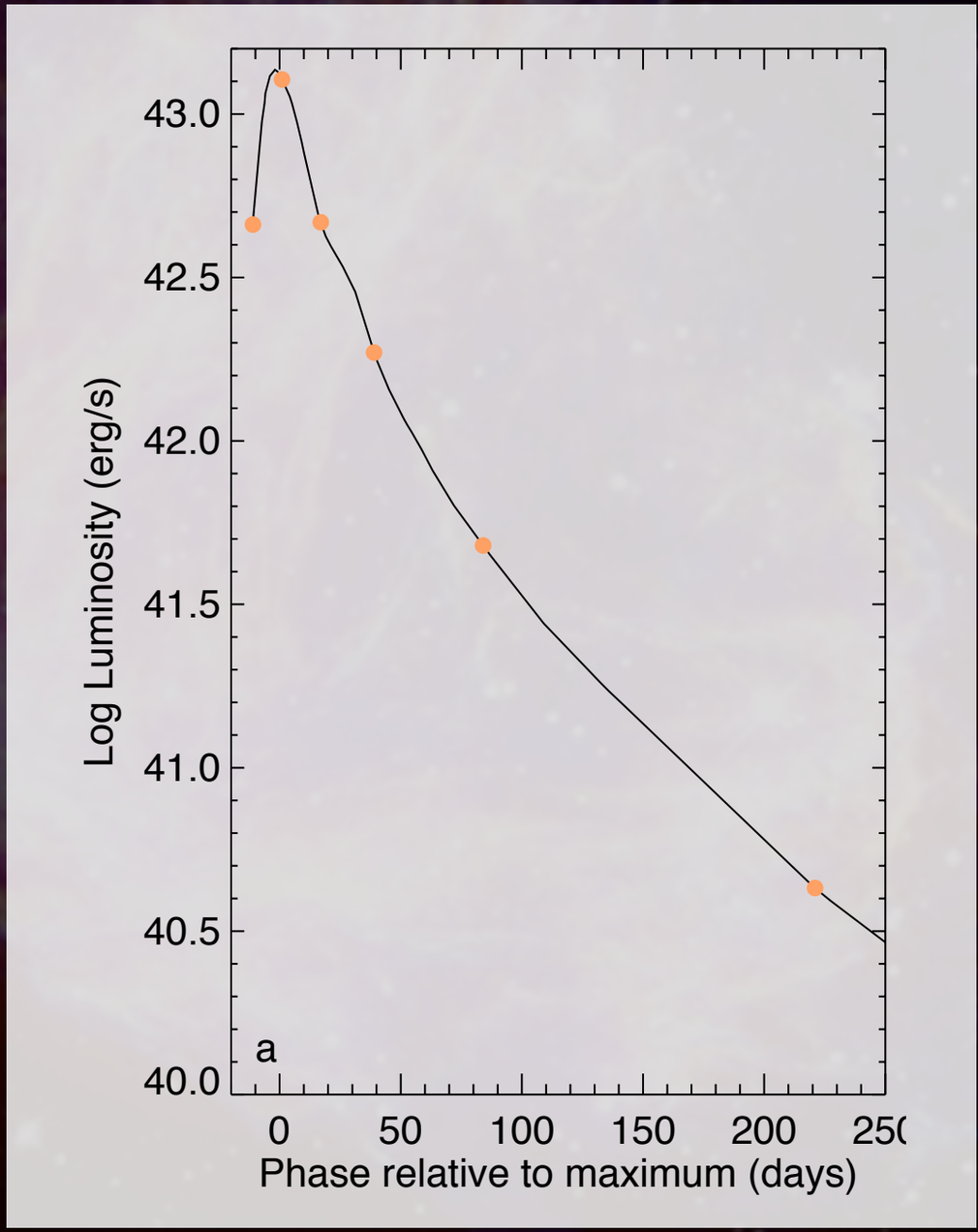
56Ni (half-life 6.1 days) to 56Co

and ultimately to 56Fe (half-life 77 days)

Gamma rays are thermalized,

~ 85% of the light is in the optical (4000Å)

SN Ia Light-curve



SN Ia

Brightest supernovae

Slow accretion

White dwarf mergers

Sub-Chandrasekhar mass explosions

Slow accretion

supersoft X-ray sources

can generate only 5% of SN Ia

White dwarf mergers

smaller white dwarf forms accretion disk

would create NS

WDs must have same mass

Sub-Chandrasekhar mass explosions

Observed ejecta mass is much lower than Chandrasekhar mass

"double detonation"

Distance measurements

better than 6%

$$m - M = 5\,\mathrm{mag} * \log\left(r / 10\ \mathrm{pc} \right)$$

m = apparent magnitude
M = absolute magnitude

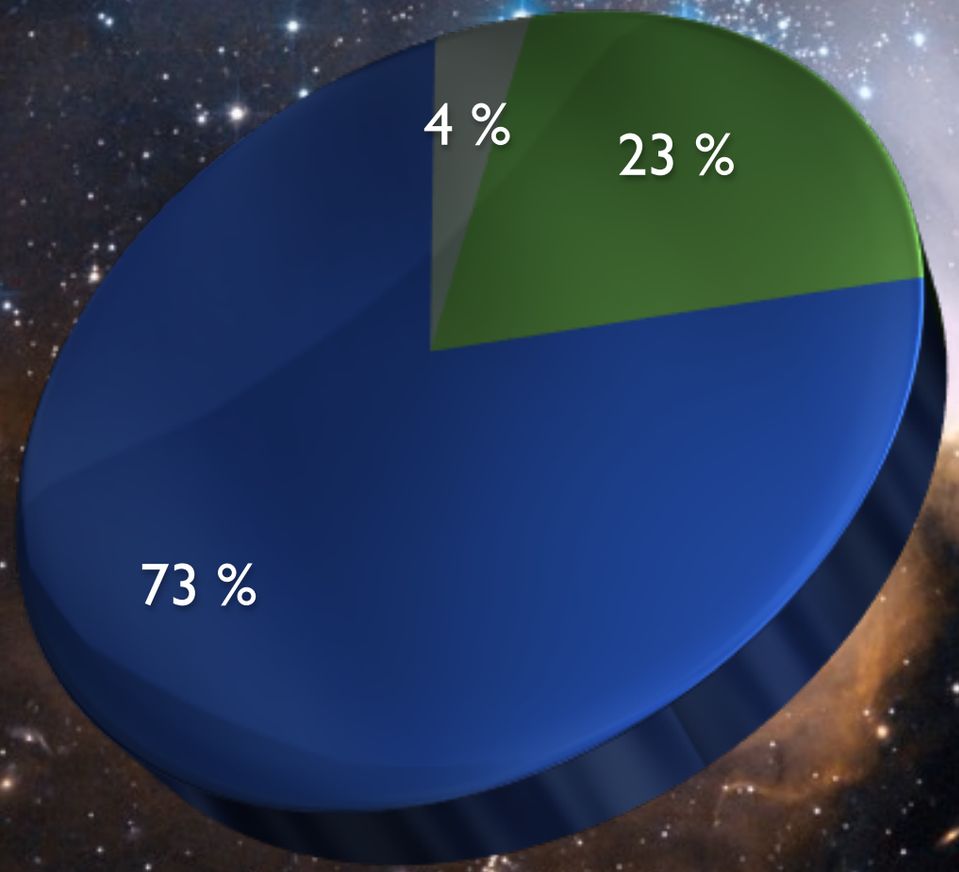
Dark Energy

Search for deceleration parameter led to discovery of acceleration

Barions

Dark Matter

Dark Energy



SN type 2

Core collapse SN

Iron core

Chandrasekhar Limit

Collapse + photo-disintegration

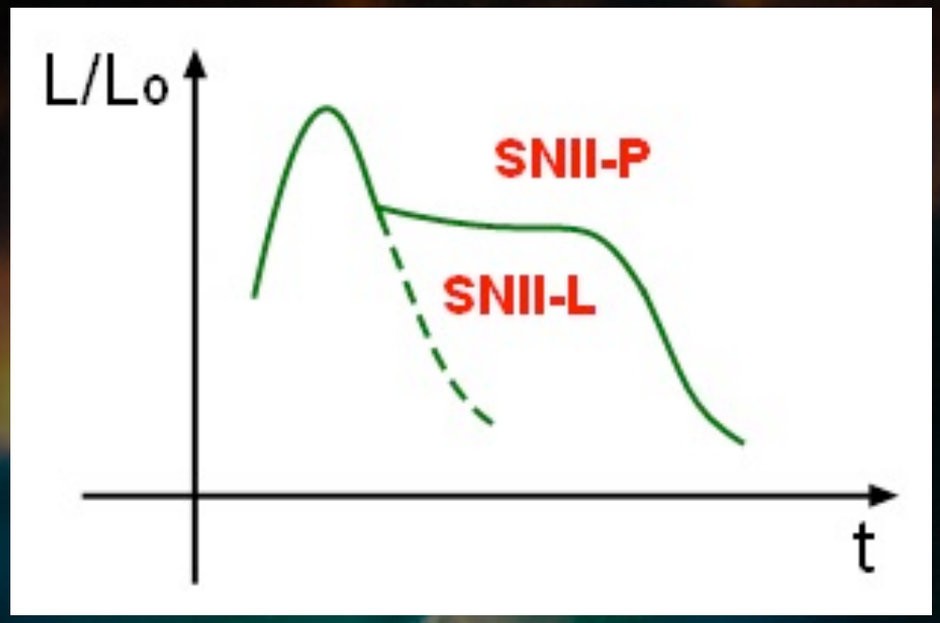
$e^- + p \Rightarrow n + \nu_e$

Degenerate neutron pressure stops core collapse

Reflection of outer layers and shock

Neutrino trapping

SN 2 Light-curves



Plateau due to ionized Hydrogen = high opacity

Linear due to expulsion of Hydrogen in progenitor

Which stars become SN 2?

Initial mass < 14 solar masses < initial mass

(traditionally 8 solar masses)

no SN

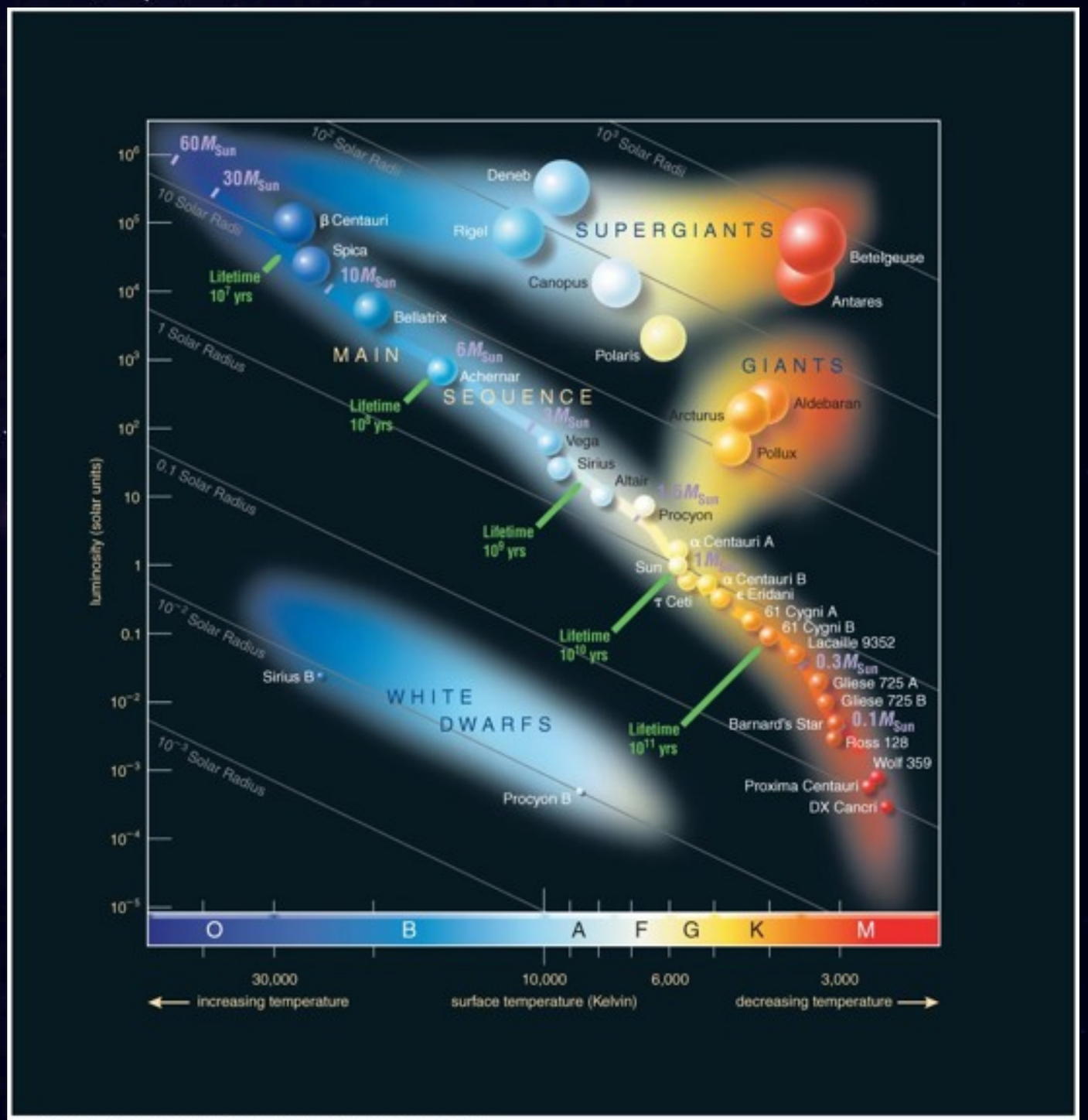
White Dwarf
(final mass < 1,4 solar masses)

Supernova explosion

Black Hole
(final mass > 3 solar masses)

Neutron Star
(final mass < 3 solar masses)

Hertzsprung-Russell-Diagram



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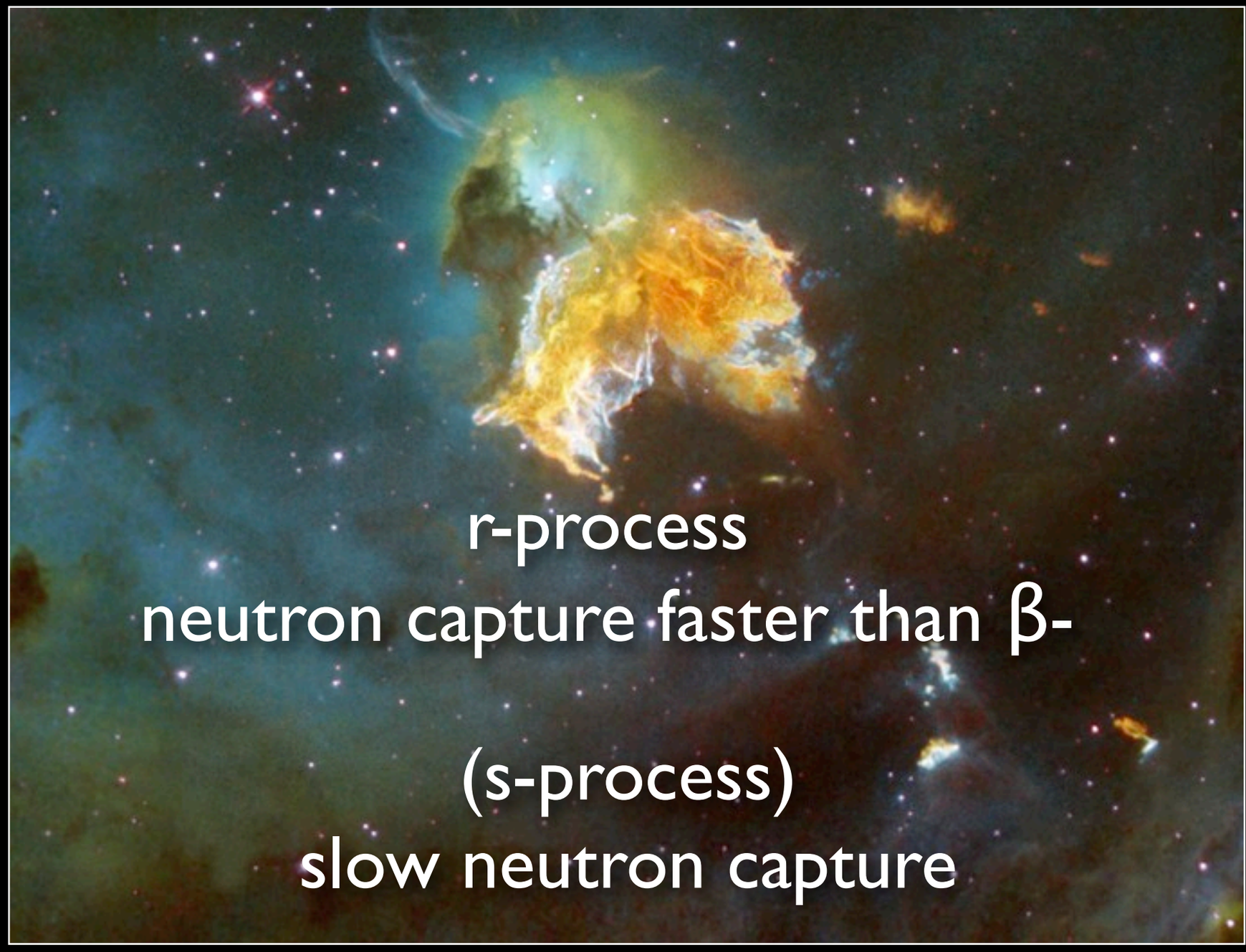
To sum up ...

Like the „stars“ here on earth,
the ones which shine the brightest,
live the shortest.

Production of heavy elements



Instabilities

Rayleigh-Taylor instability

inverse gravity

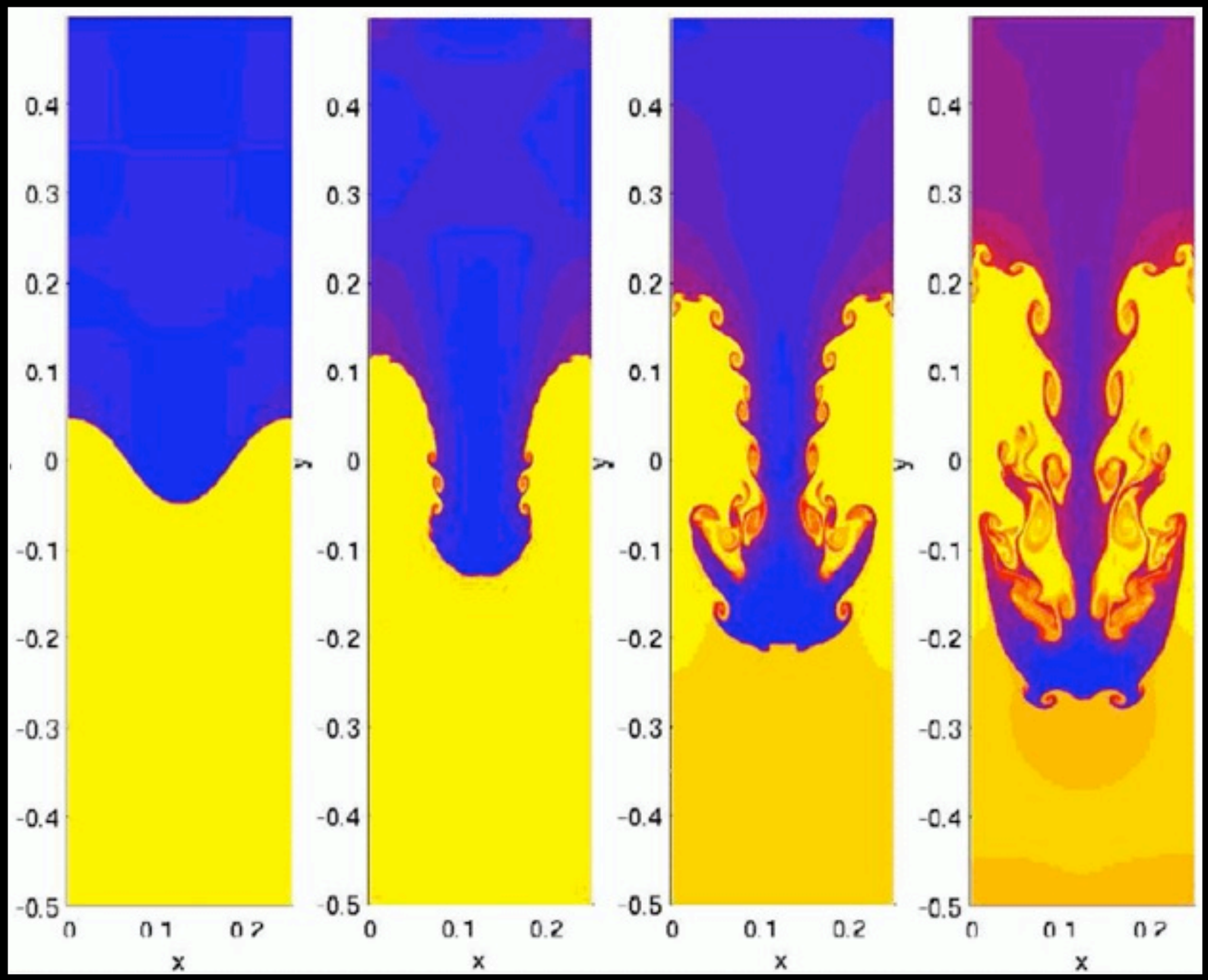
„fingers“

Kelvin-Helmholtz instability

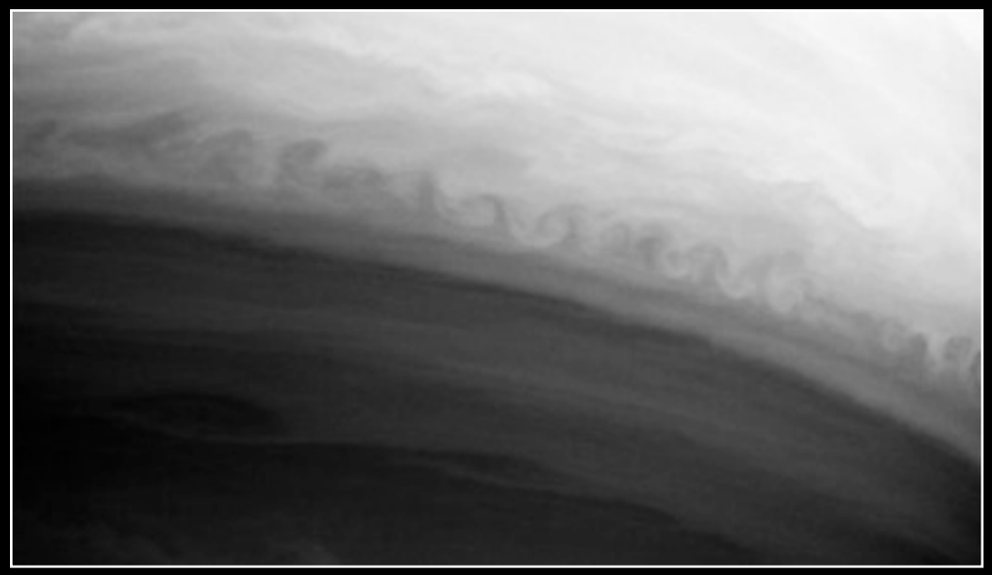
shear

transition to turbulent flow

Rayleigh-Taylor instability



Kelvin-Helmholtz instability



movie

Conclusion

Supernova include all aspects from physics

very complicated to simulate

new SN1a scenario?

standard candles

production of heavy elements

much more research must be done...