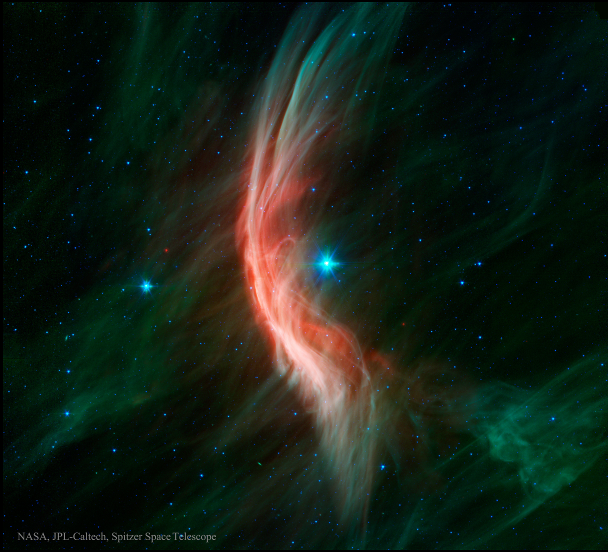
LIVE FAST AND DIE YOUNG

EVOLUTION AND FATE OF MASSIVE STARS

Mathieu Renzo



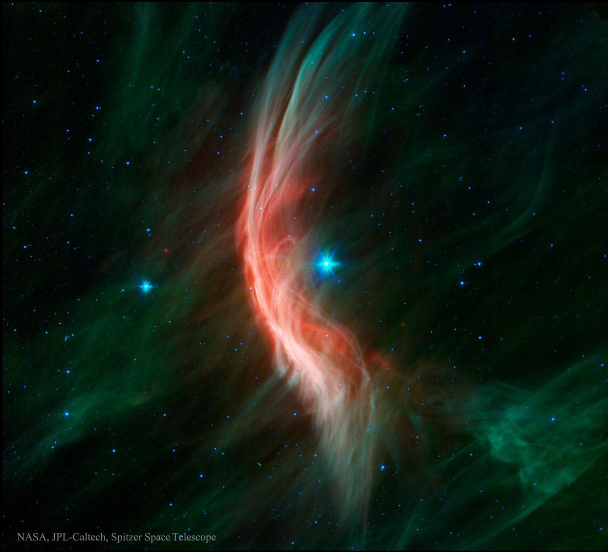
Columbia University

Flatiron Institute
Center for Computational Astrophysics

Why care about massive stars?

They shape
their environment

Feedback



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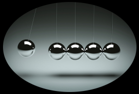
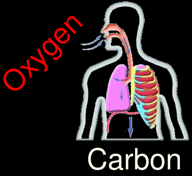
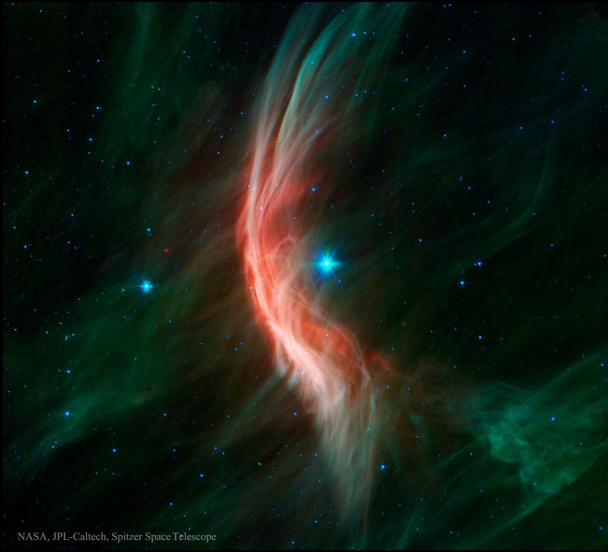
Radiative



Mechanical

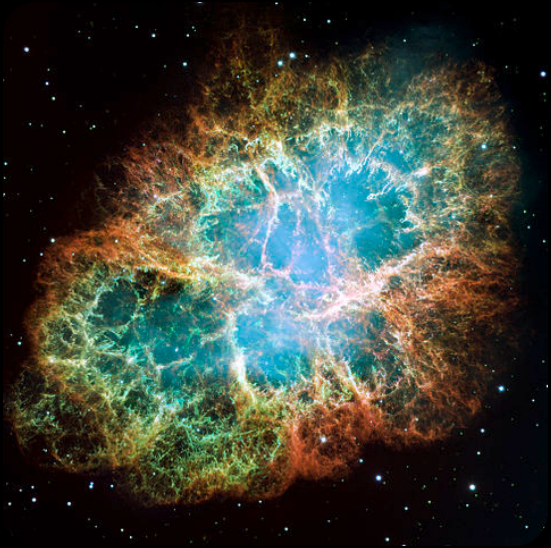


Chemical



Why care about massive stars?

They “die” by exploding as supernovae



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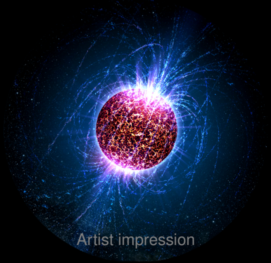
Live fast 1/3:

Sun lifetime : human $\simeq$ massive stars : butterfly

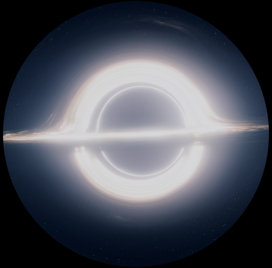
10 **B**illion yrs : 100 yrs $\simeq$ 10 **M**illion yrs : day-week

The death of massive stars

(failed) core collapse **Supernova**



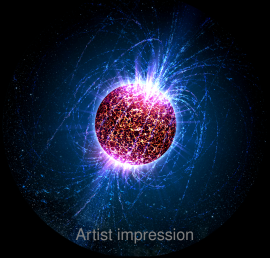
Neutron star



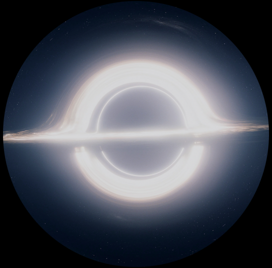
Black hole

The death of the most massive stars

(failed) core collapse **Supernova**



Neutron star

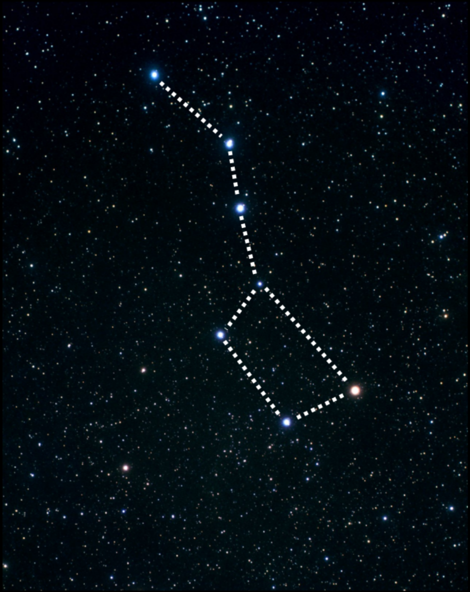


Black hole

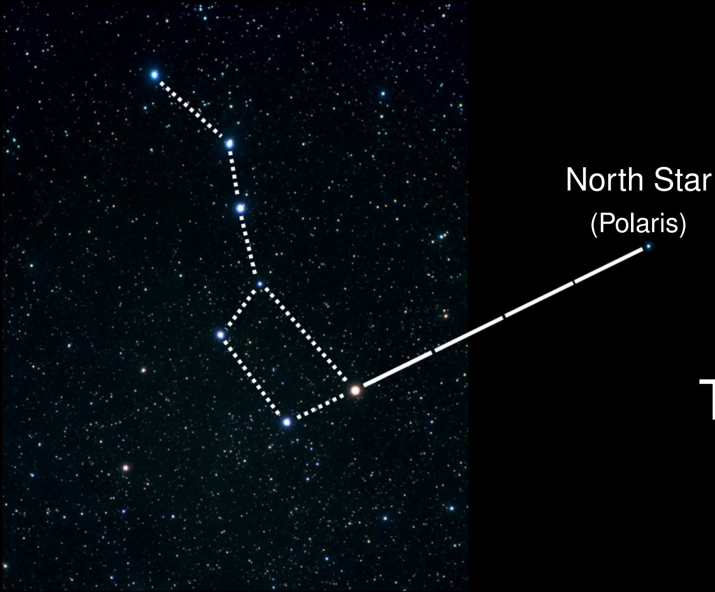
(pulsational) pair-instability

Most massive stars are in interacting binaries

Artist impression
Credits: ESO, L. Calçada, M. Kornmesser, S.E. de Mink



The big dipper

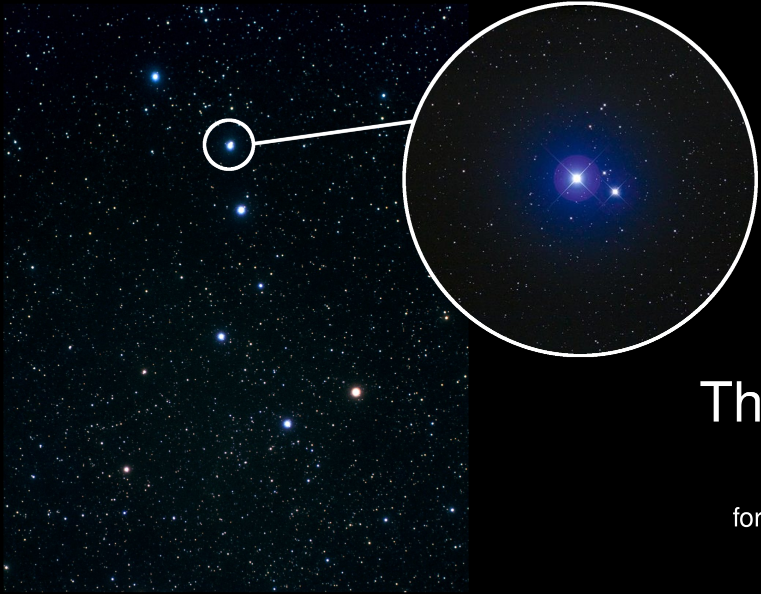


The big dipper

The big dipper

as eyesight test

for ancient astronomers



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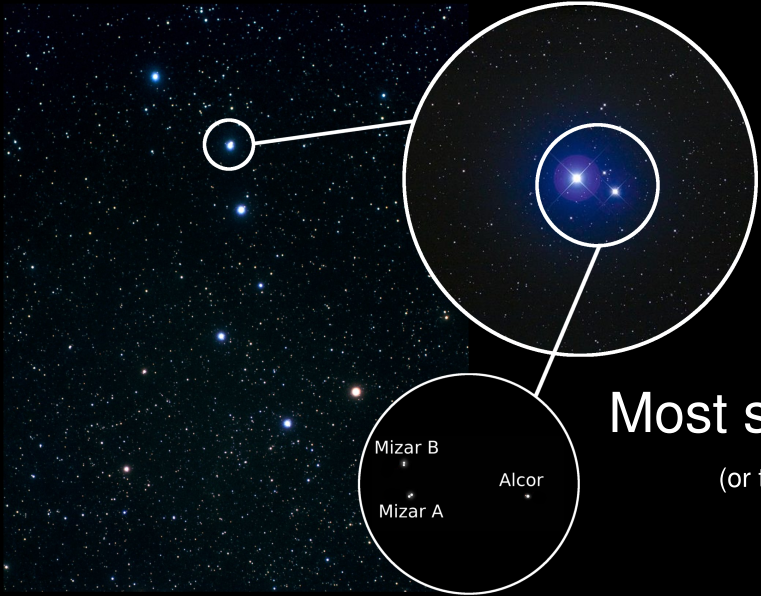

Unlike the Sun

Most stars are binaries

(or triples, quadruples, etc...)

Live fast 2/3: supernova in a binary

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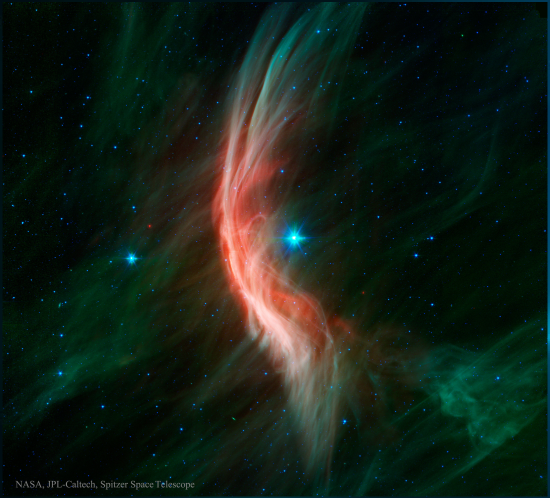
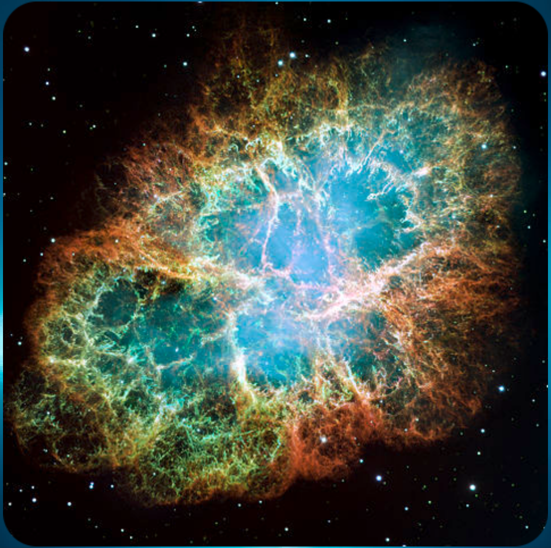
Live fast 2/3: supernova in a binary





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Live fast 3/3: dynamical ejections

Stars are born in densely populated clusters

Runaways are common, easy to see, and provide constrains on...

Binary disruption

... binary interactions

... explosions & BH formation (kicks)

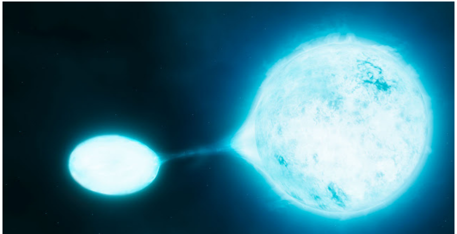
... masses of field stars

Cluster ejections

... initial binary fraction

... clusters formation

... dynamical formation of binary BH



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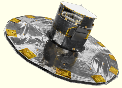
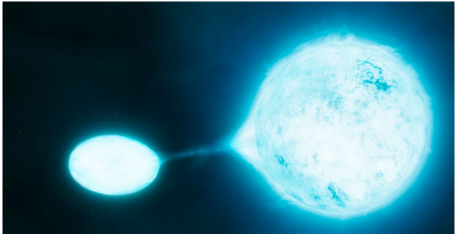
Need to distinguish the two channels

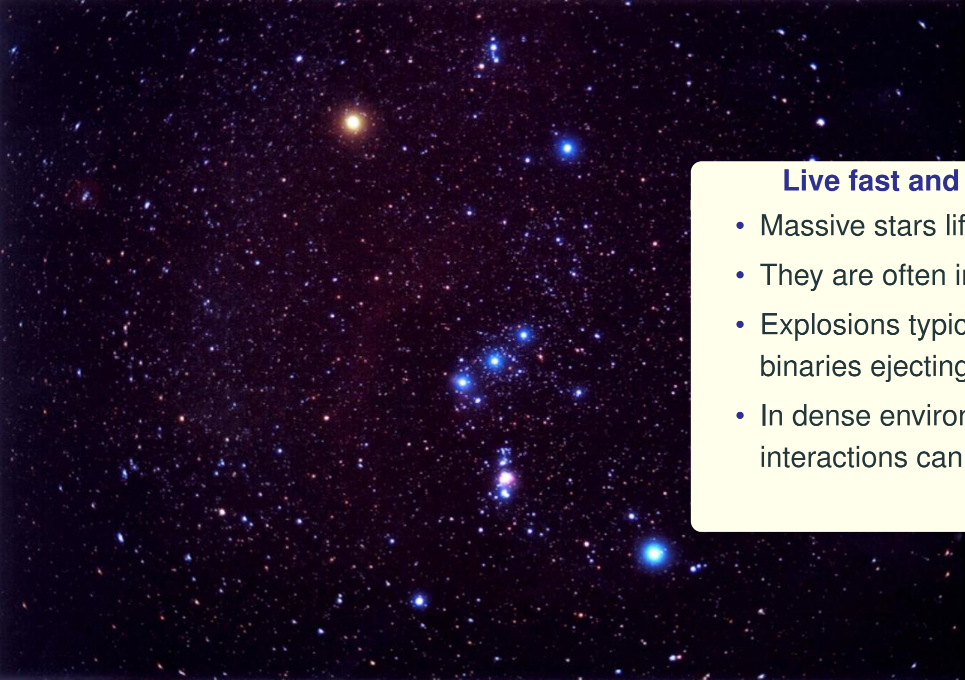
- ESA *Gaia* telescope
- Model the internal evolution and appearance



gaia

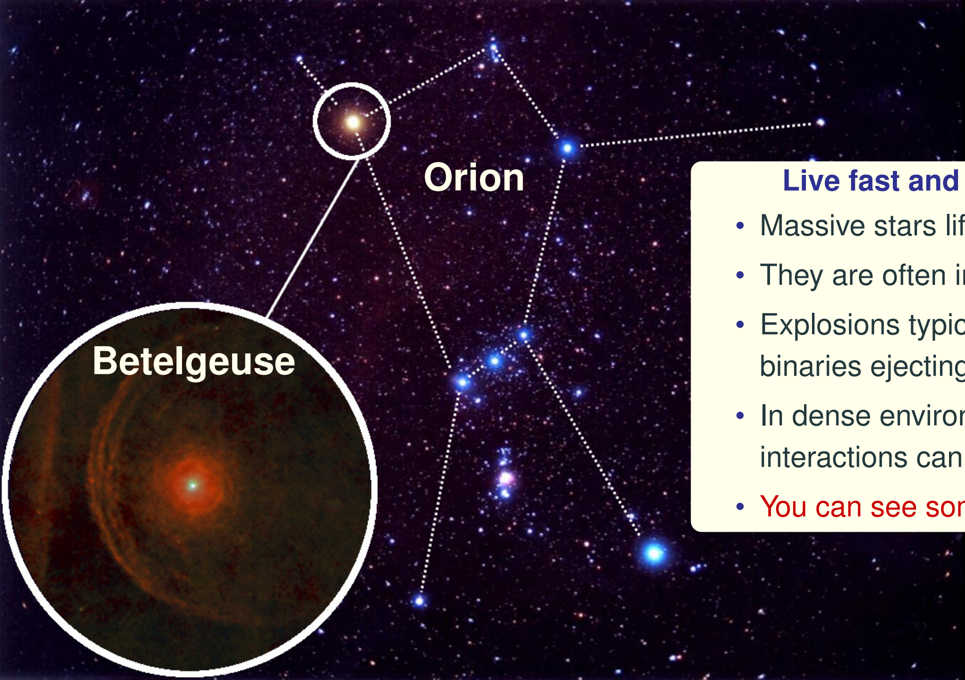


Backup slides



Live fast and die young

- Massive stars lifetime are short
- They are often in binaries
- Explosions typically break the binaries ejecting the companion
- In dense environments, N-body interactions can also eject stars



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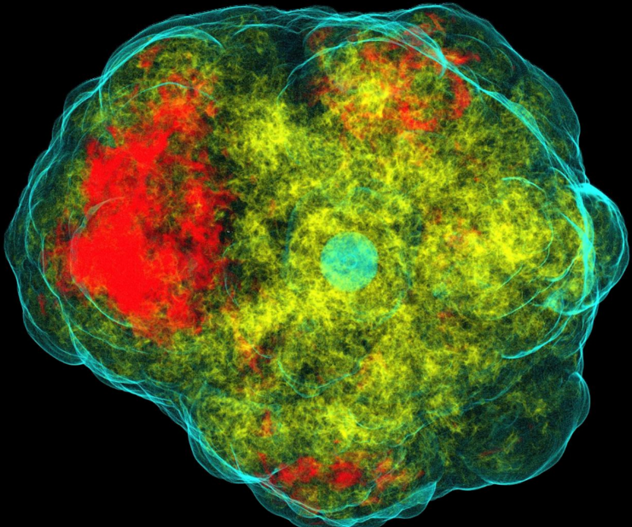
- You can see some by naked eye!

SN natal kick

Observationally: $v_{\mathrm{pulsar}} \gg v_{\mathrm{OB-stars}}$

Physically: ν emission and/or ejecta anisotropies



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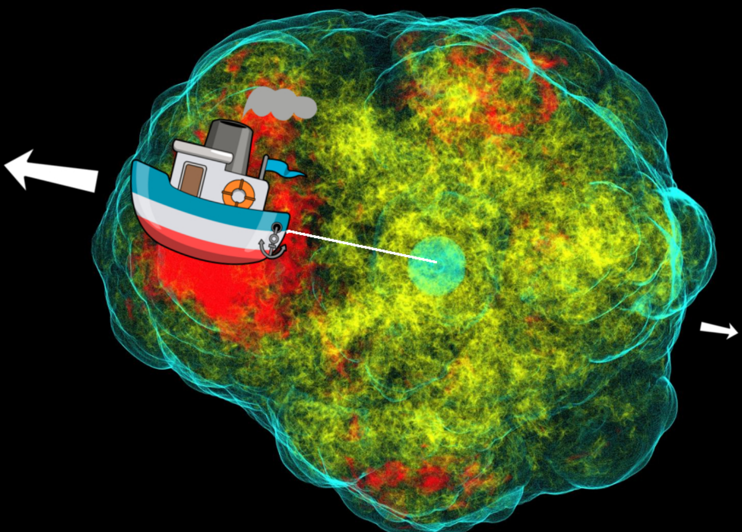

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