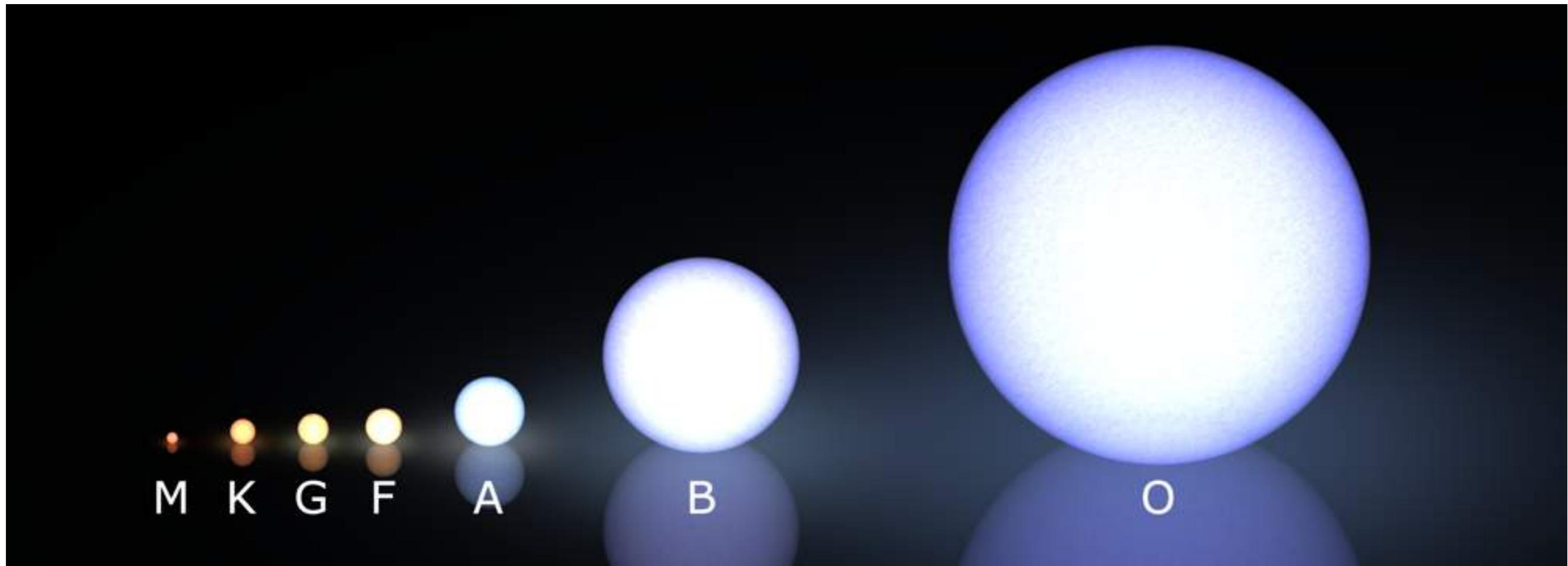


Different types of stars



▶ spectral types

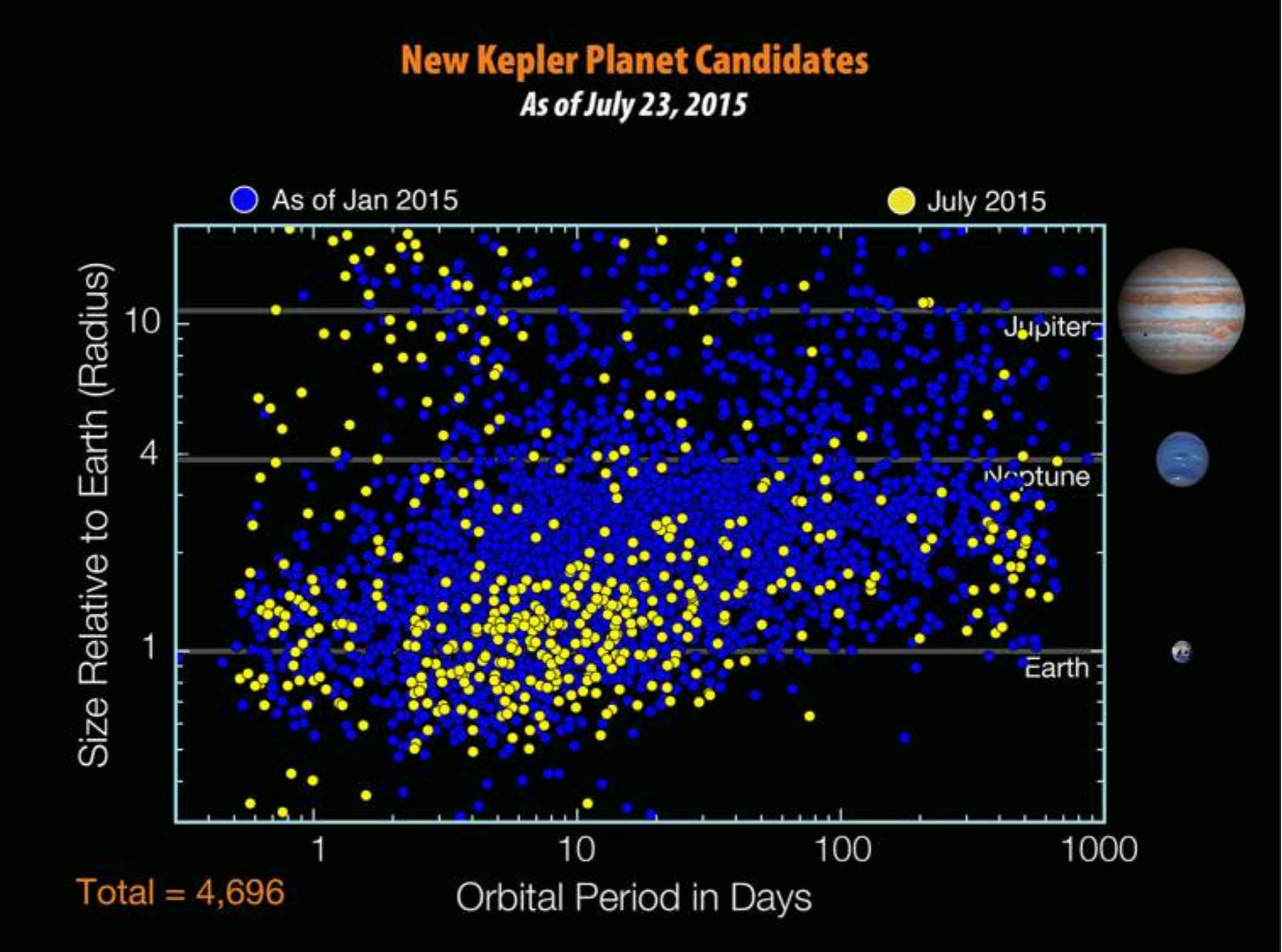
▶ relationships between stellar mass, luminosity, and temperature

Binary stars



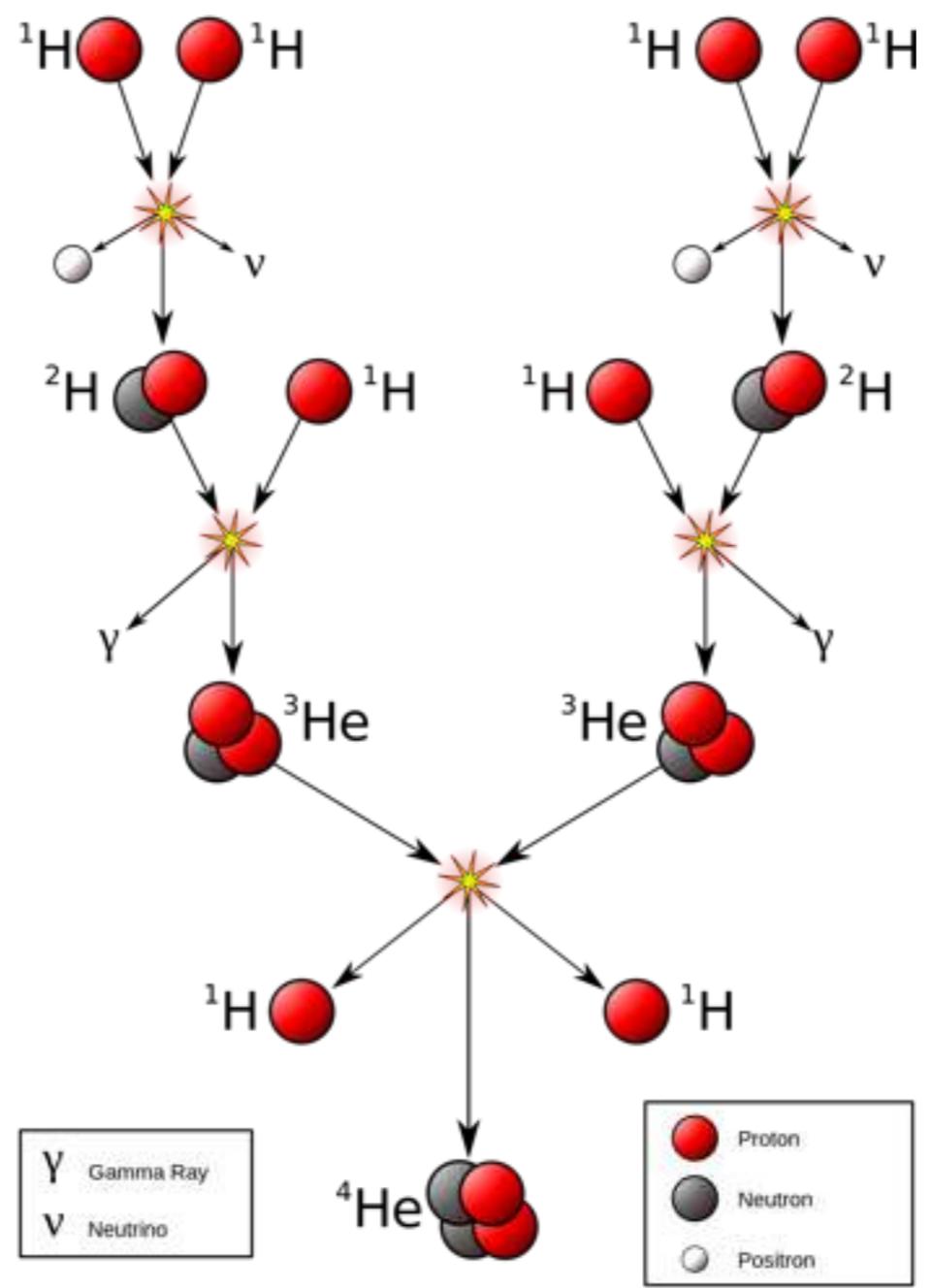
- ▶ different types of binaries: visual, spectroscopic, eclipsing
- ▶ measuring orbital parameters
- ▶ measuring stellar masses

Extra solar planets



► how do we detect and measure the properties of planets around other stars?

Nuclear energy generation in stars

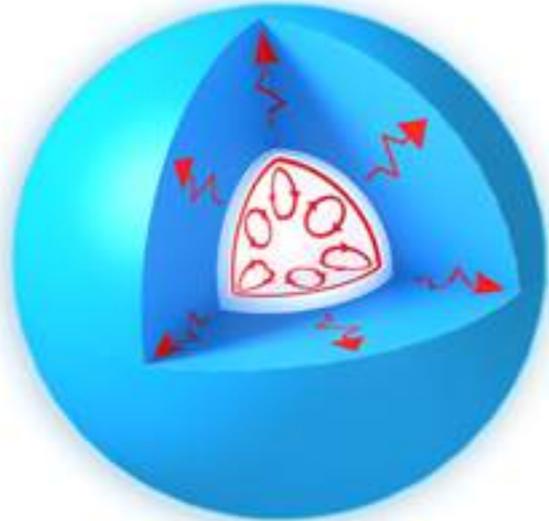


► how do stars shine?

Stellar structure

Heat Transfer of Stars

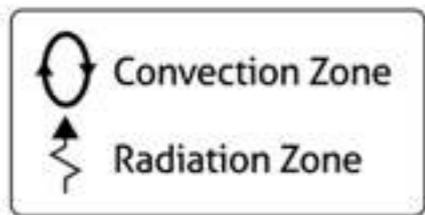
> 1.5 solar masses



0.5 - 1.5 solar masses

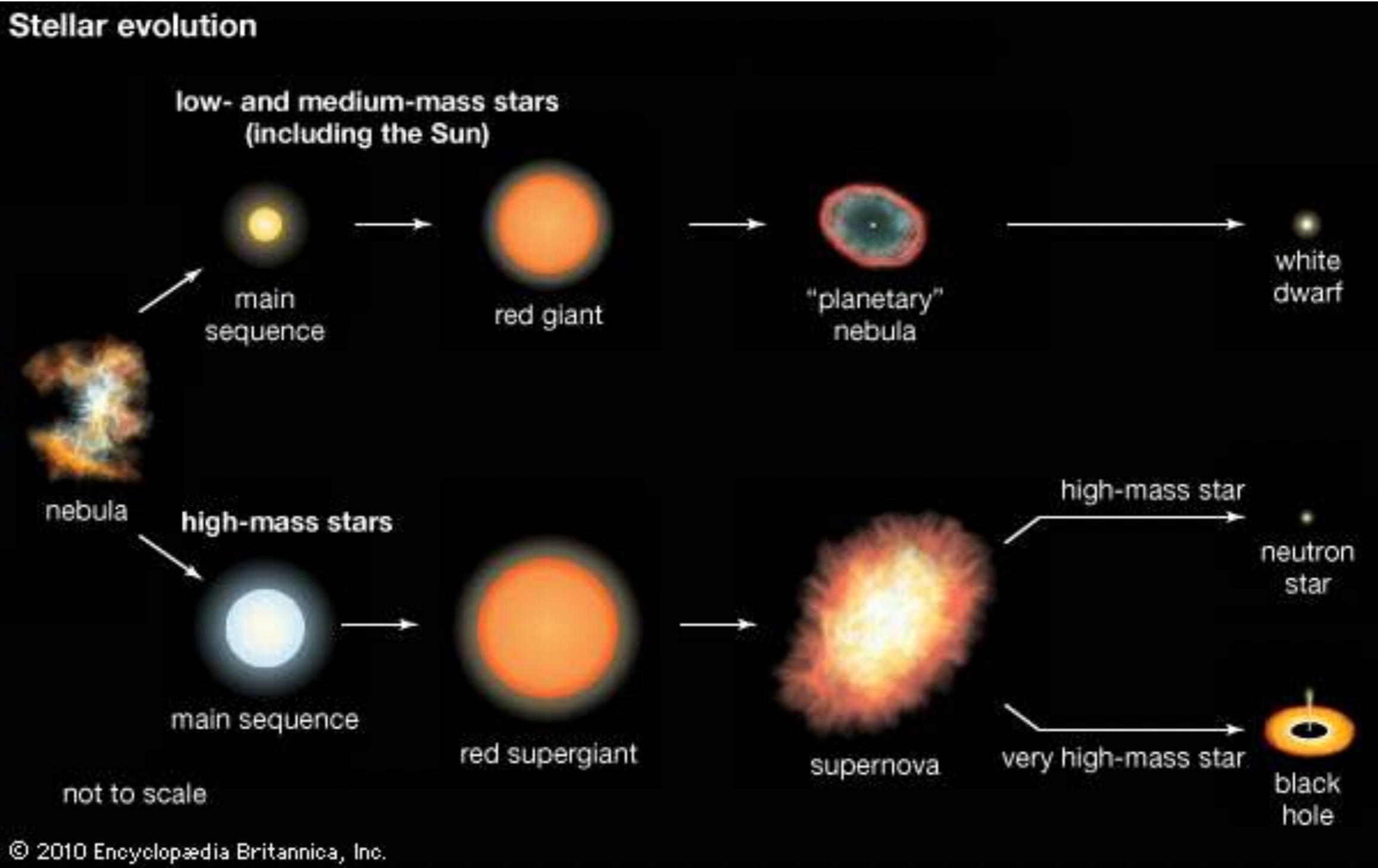


< 0.5 solar masses



- ▶ what determines the internal structure of stars?
- ▶ how is energy transported from the core to the surface?

The end points of stellar evolution



► what happens when stars run out of nuclear fuel?

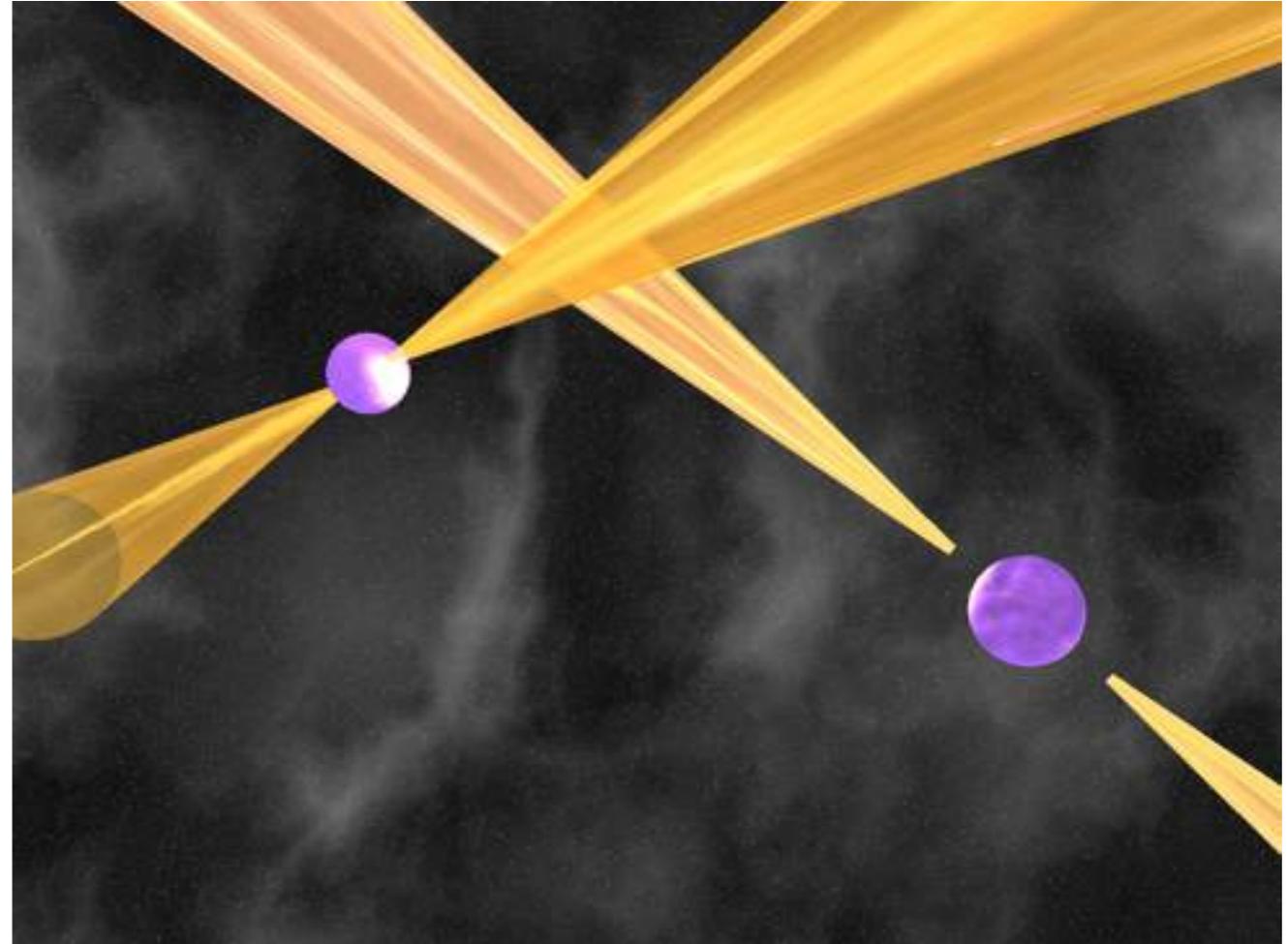
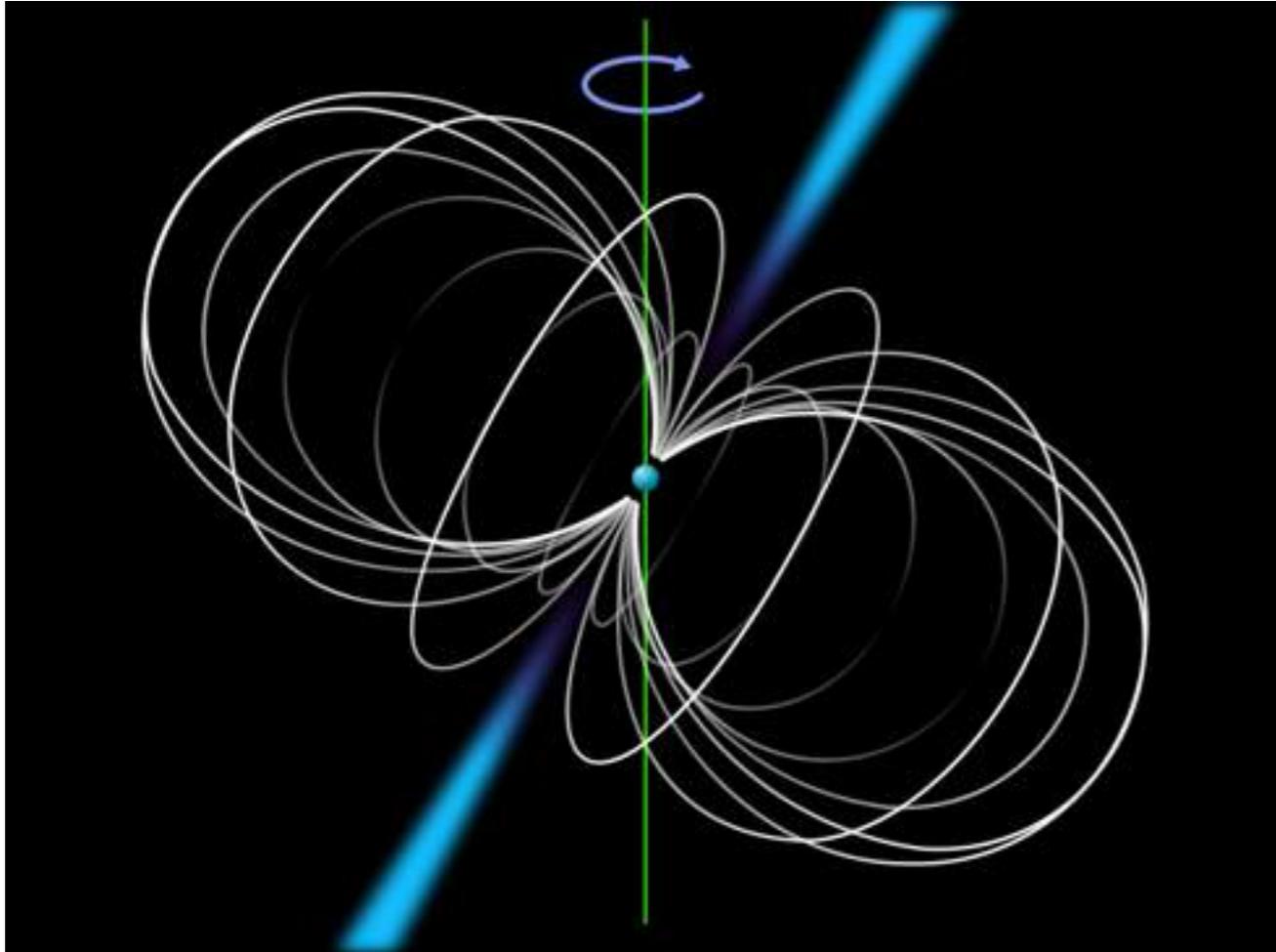
White dwarfs



www.eso.org

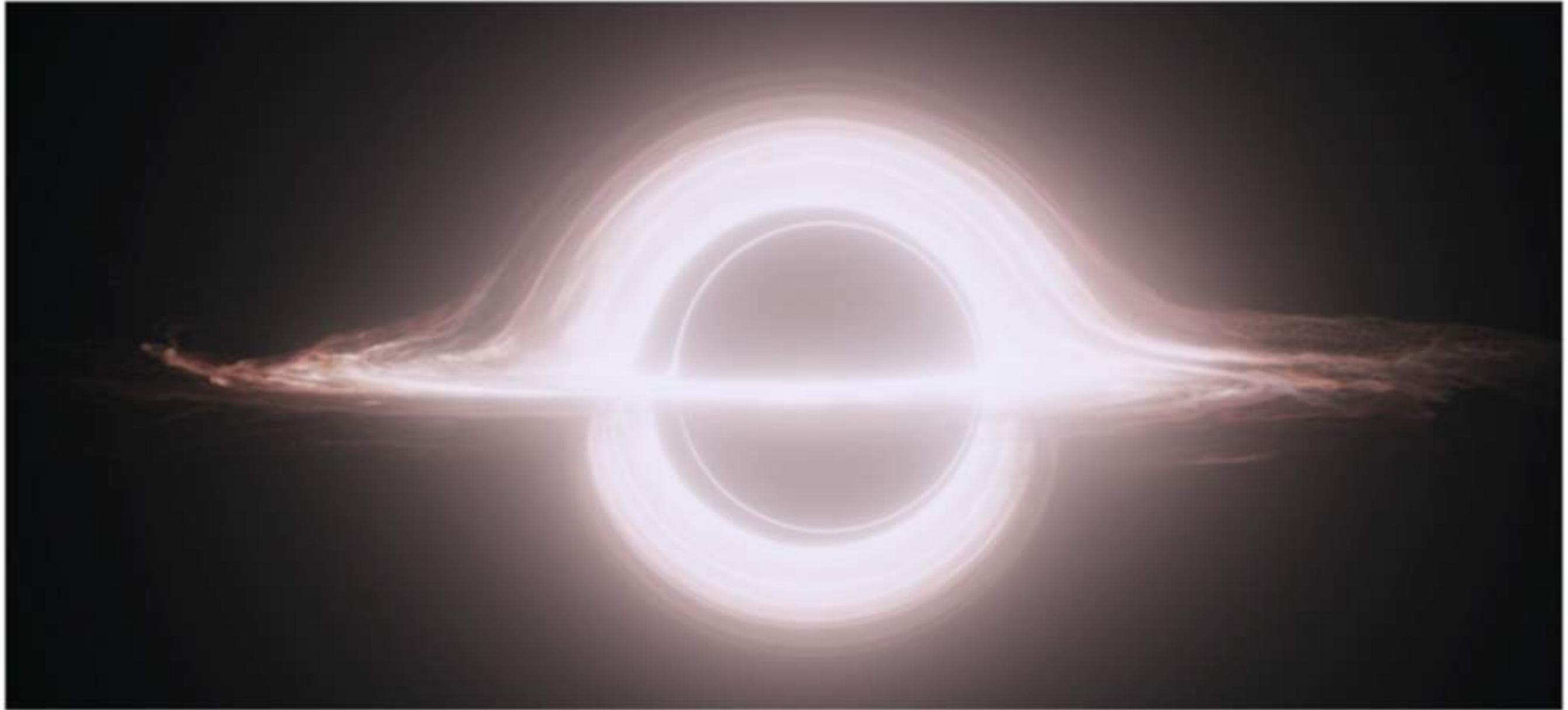
- ▶ what supports stars against runaway gravitational collapse when they can no longer produce nuclear energy? the role of quantum mechanics
- ▶ maximum mass ($1.4 M_{\text{sun}}$) for WDs
- ▶ what happens when a WD exceeds this mass? Type Ia supernovae

Neutron stars



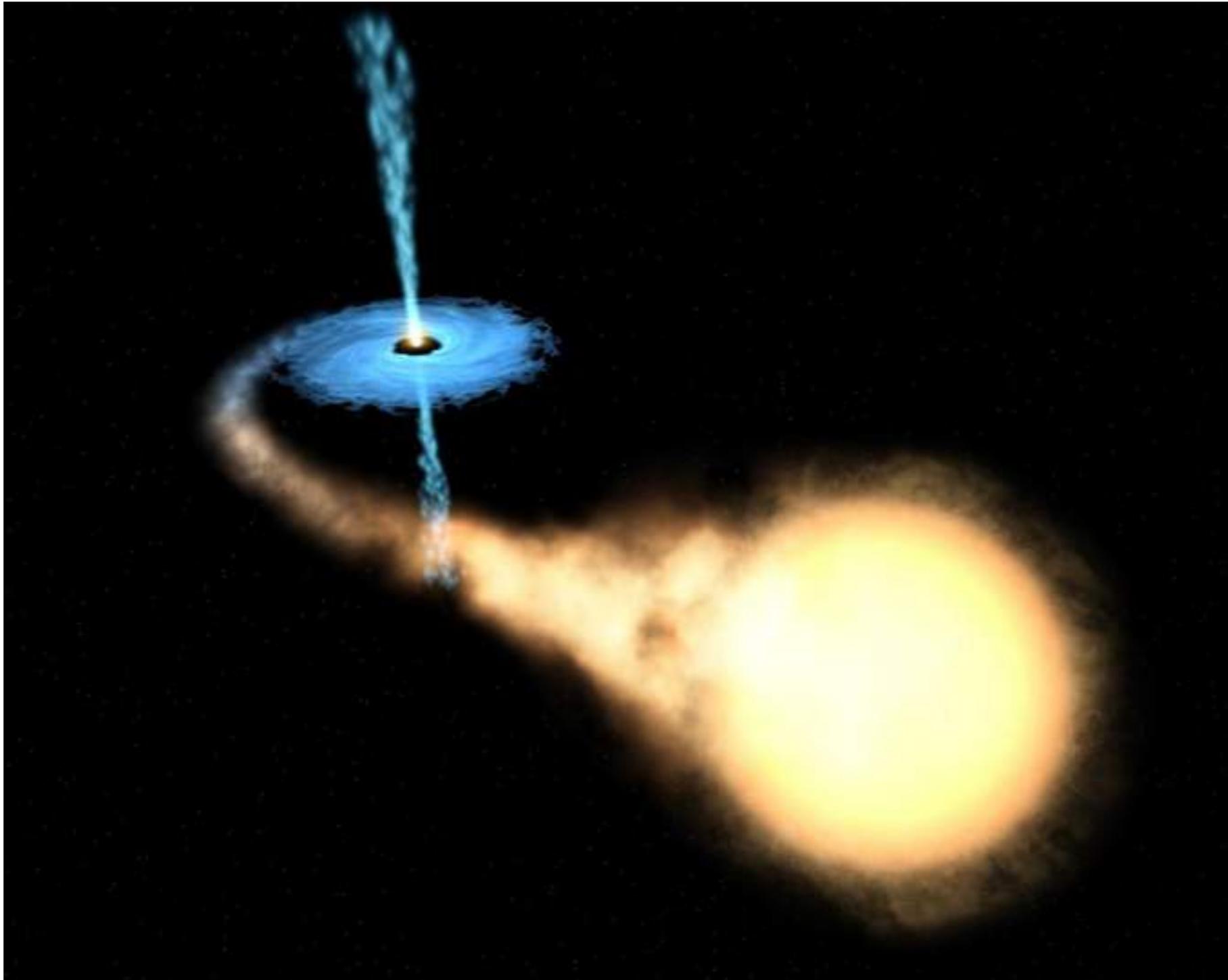
- ▶ ultra-dense, highly magnetized, rapidly rotating ($P \sim 10^{-3} - 10$ s) radio sources
- ▶ tests of Einstein's relativity using binary pulsars

Black holes



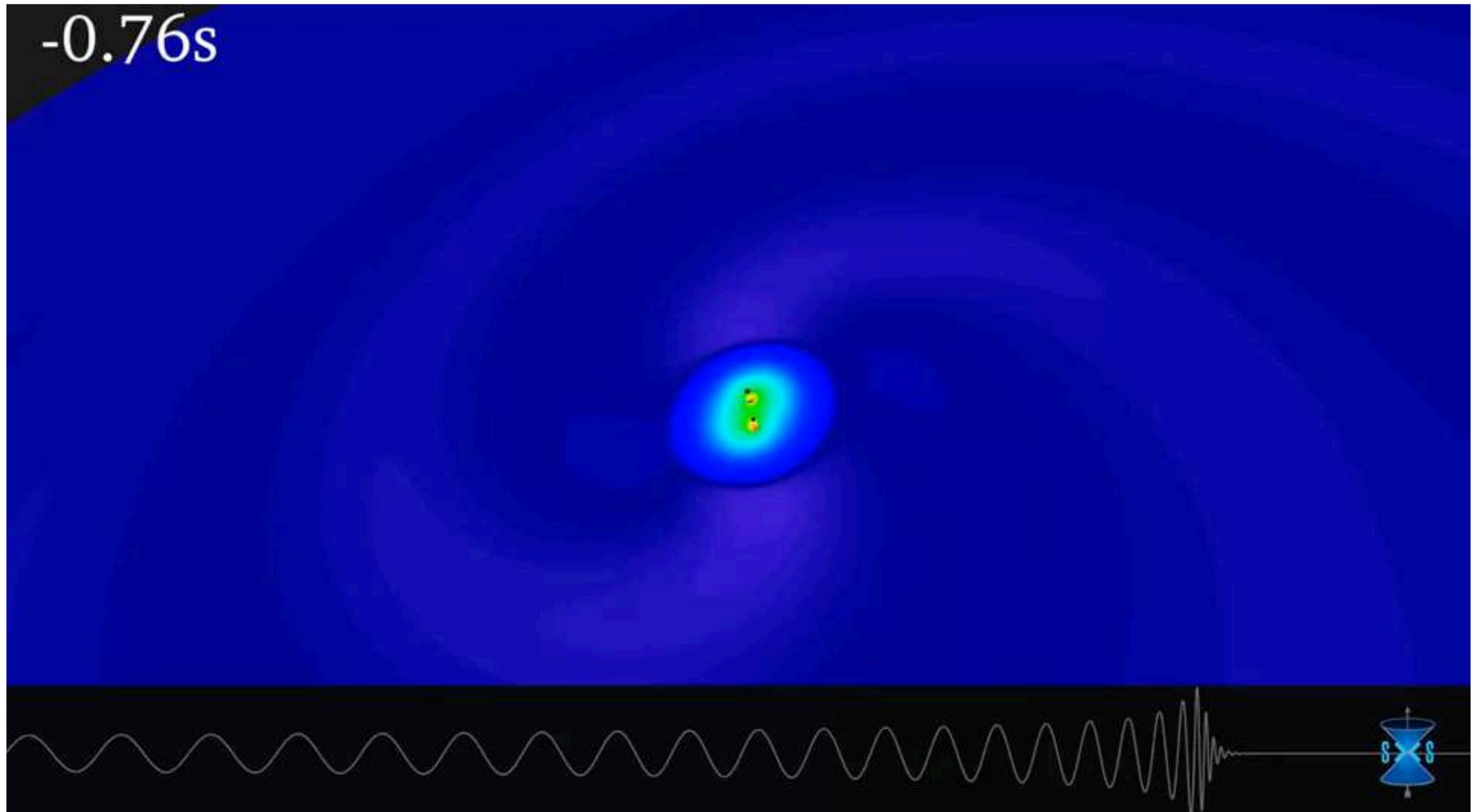
- ▶ what are black holes?
- ▶ how do they form?

Accreting black holes



- ▶ accretion disks
- ▶ winds and jets

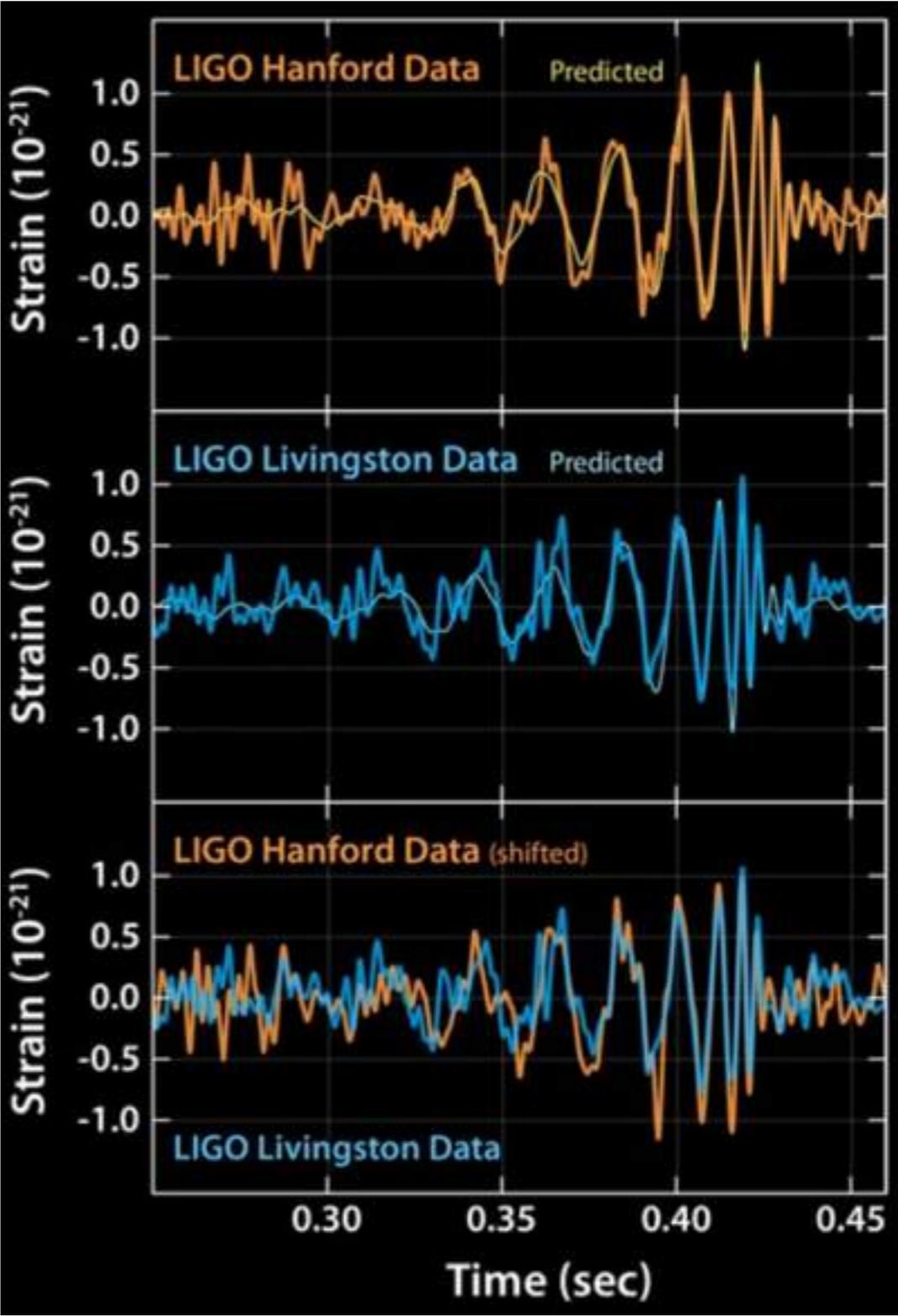
Gravitational waves



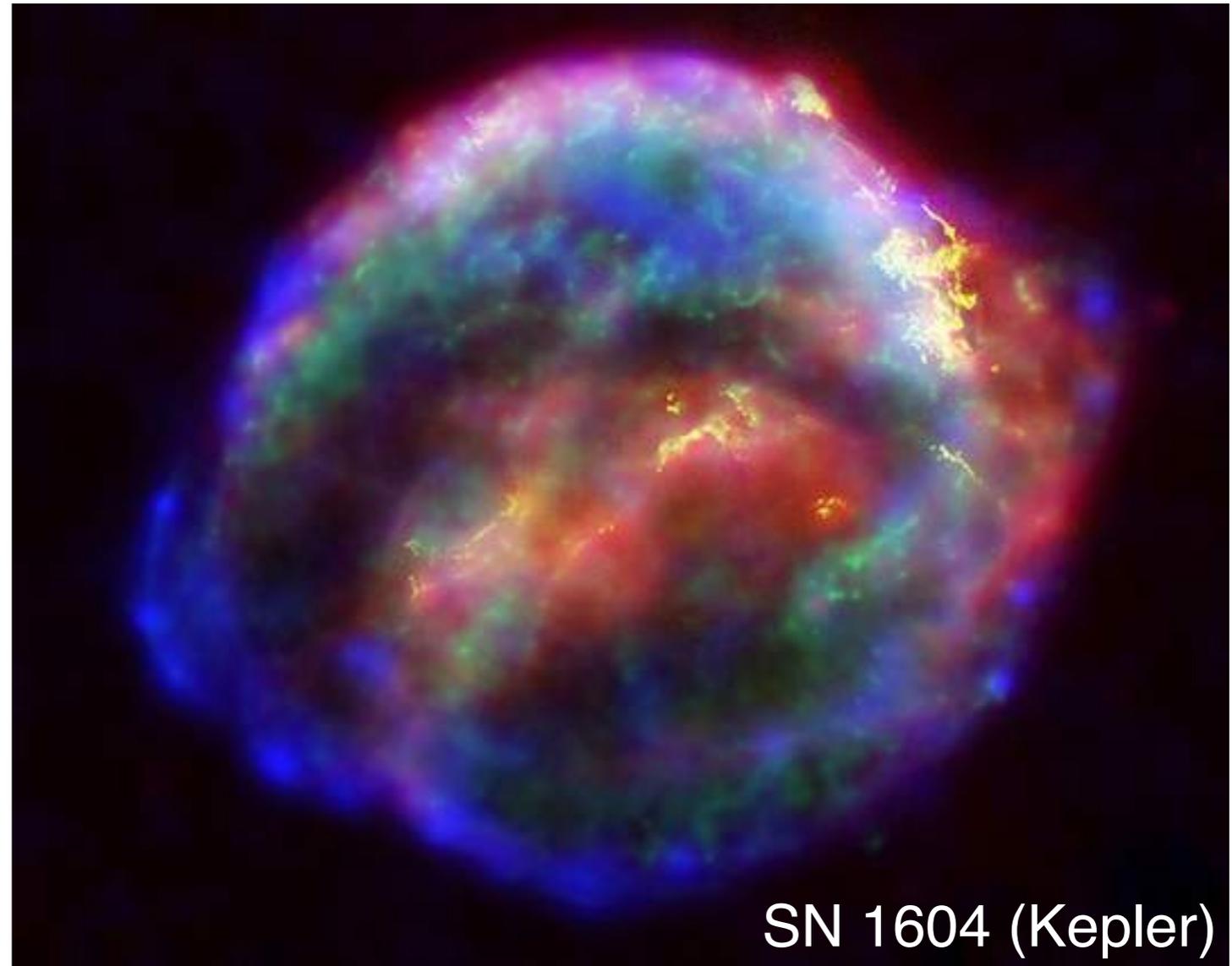
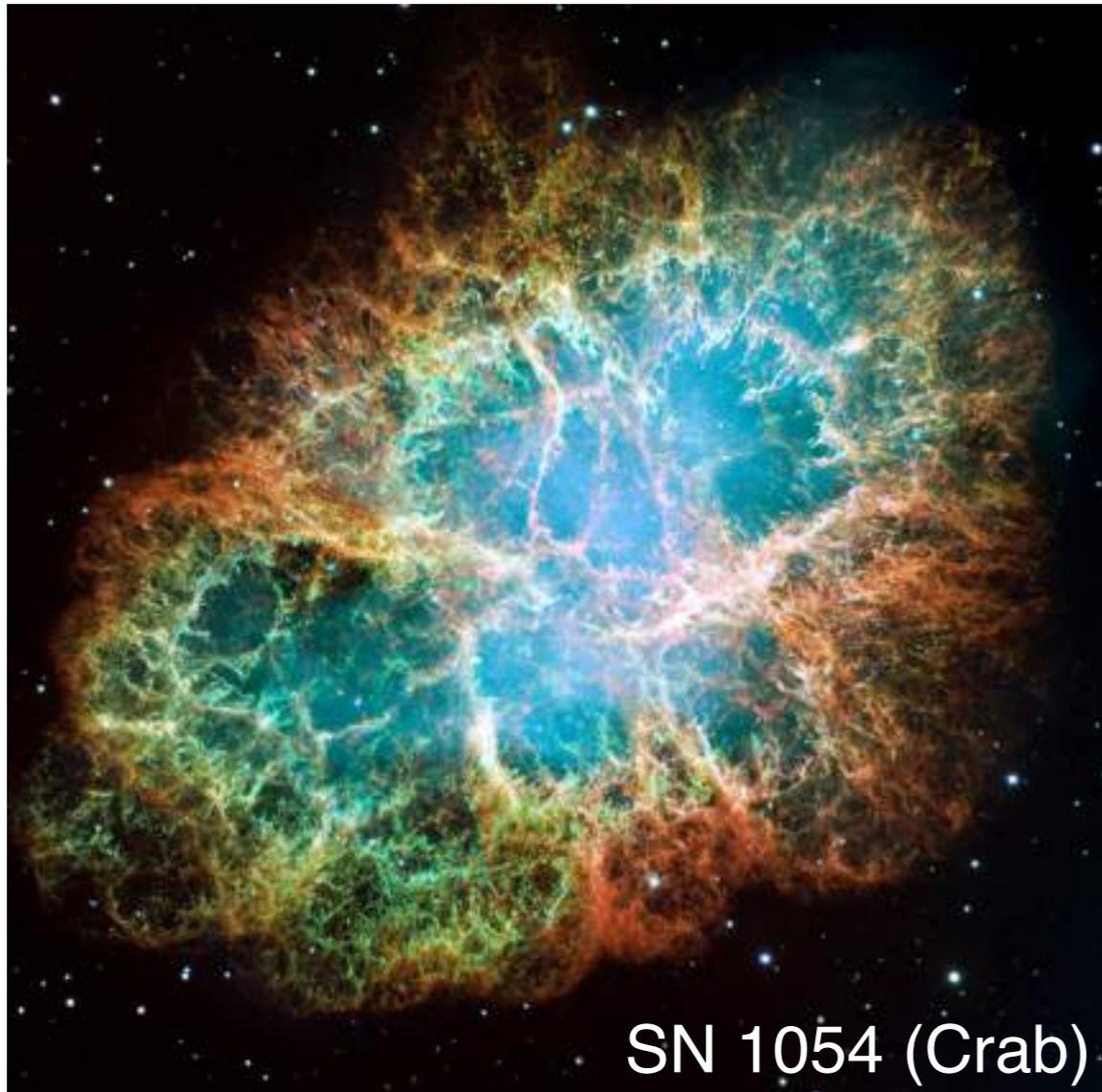
- ▶ what are gravitational waves? how are they produced

Detecting gravitational waves

Sept 14, 2015 binary BH signal

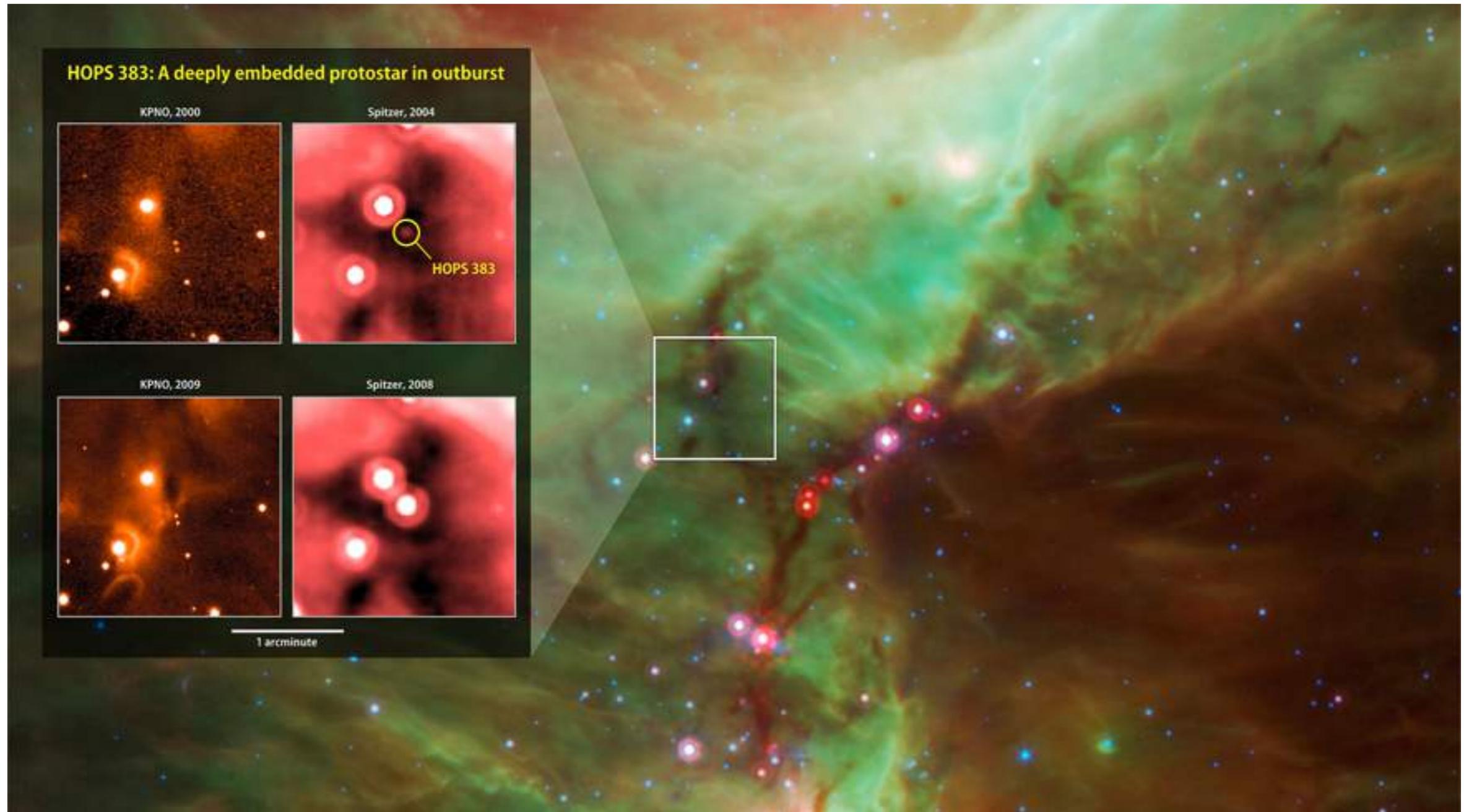


Supernovae and their remnants



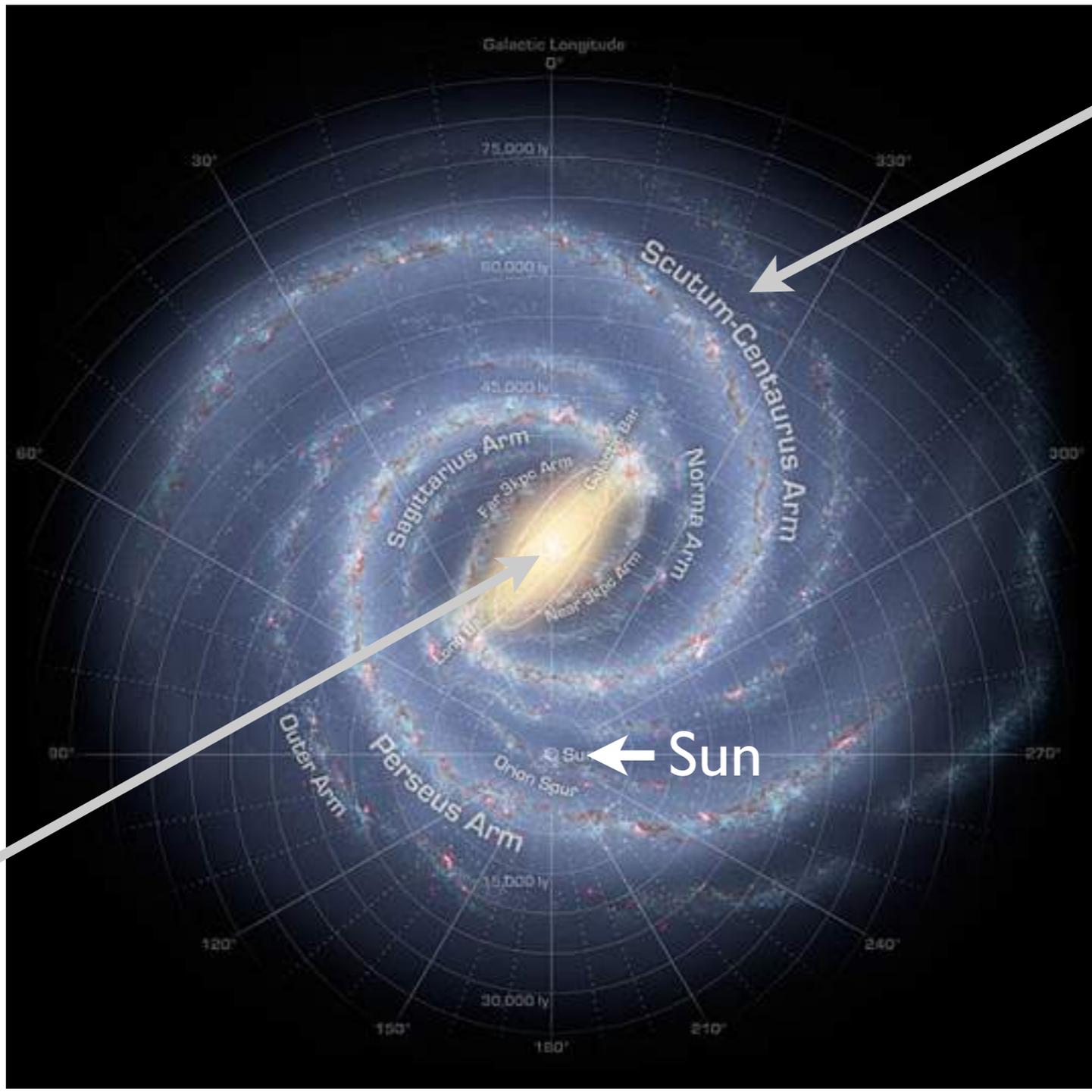
- ▶ the physics of shock waves
- ▶ acceleration of relativistic particles (cosmic rays)

Star formation and the interstellar medium



- ▶ gas and dust between stars
- ▶ how do stars form?

Our Galaxy, the Milky Way



disk of stars,
dust, and gas
 $\sim 10^{11}$ stars

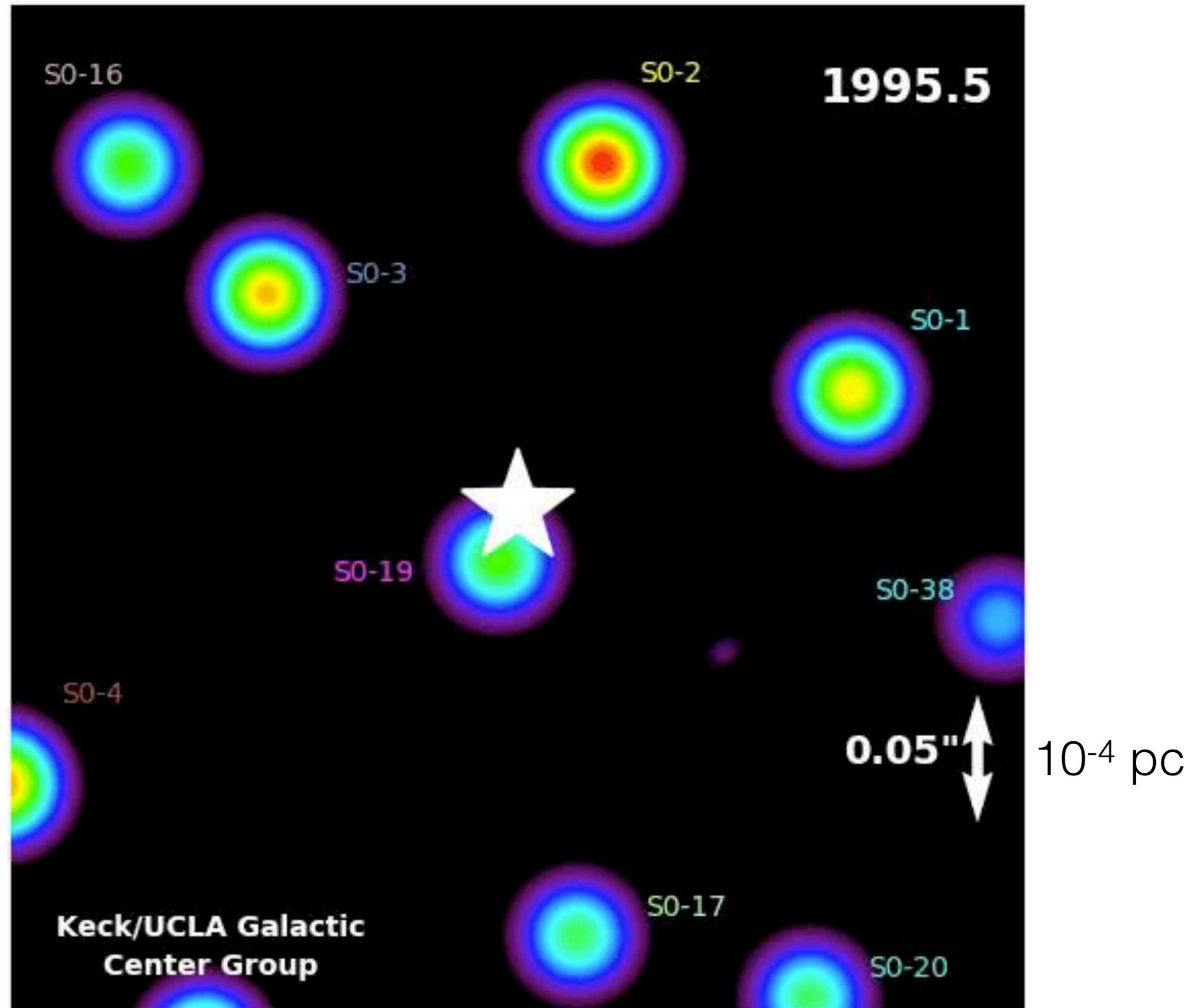
8 kpc
1 pc \approx 3 ly

$4 \times 10^6 M_{\text{sun}}$
black hole

← Sun

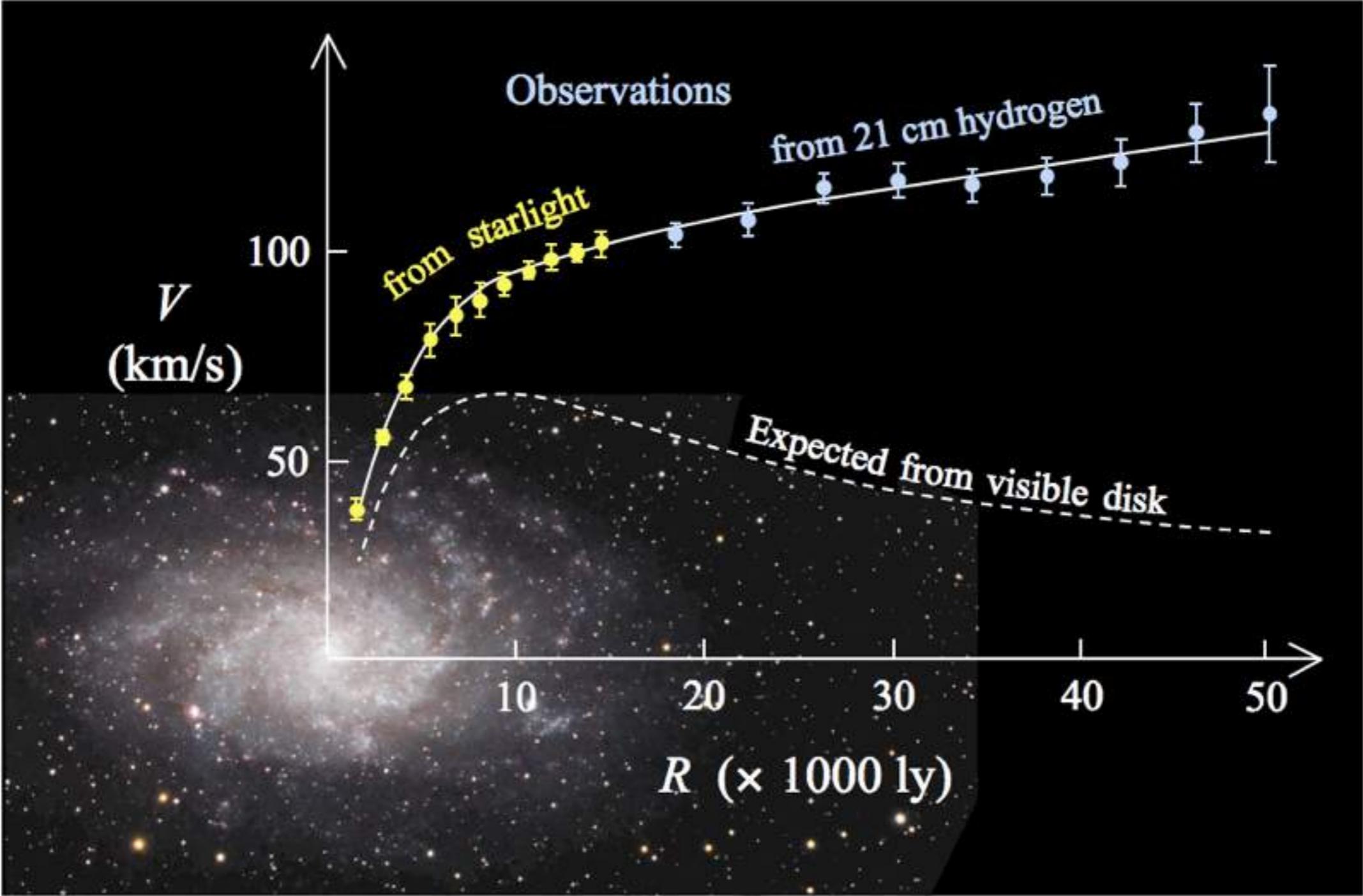
Gravity turns gas into stars
(all in a halo of dark matter)

The supermassive black hole at the Galactic center



- ▶ how do we know there is a supermassive black hole? measure its mass?

Dark matter



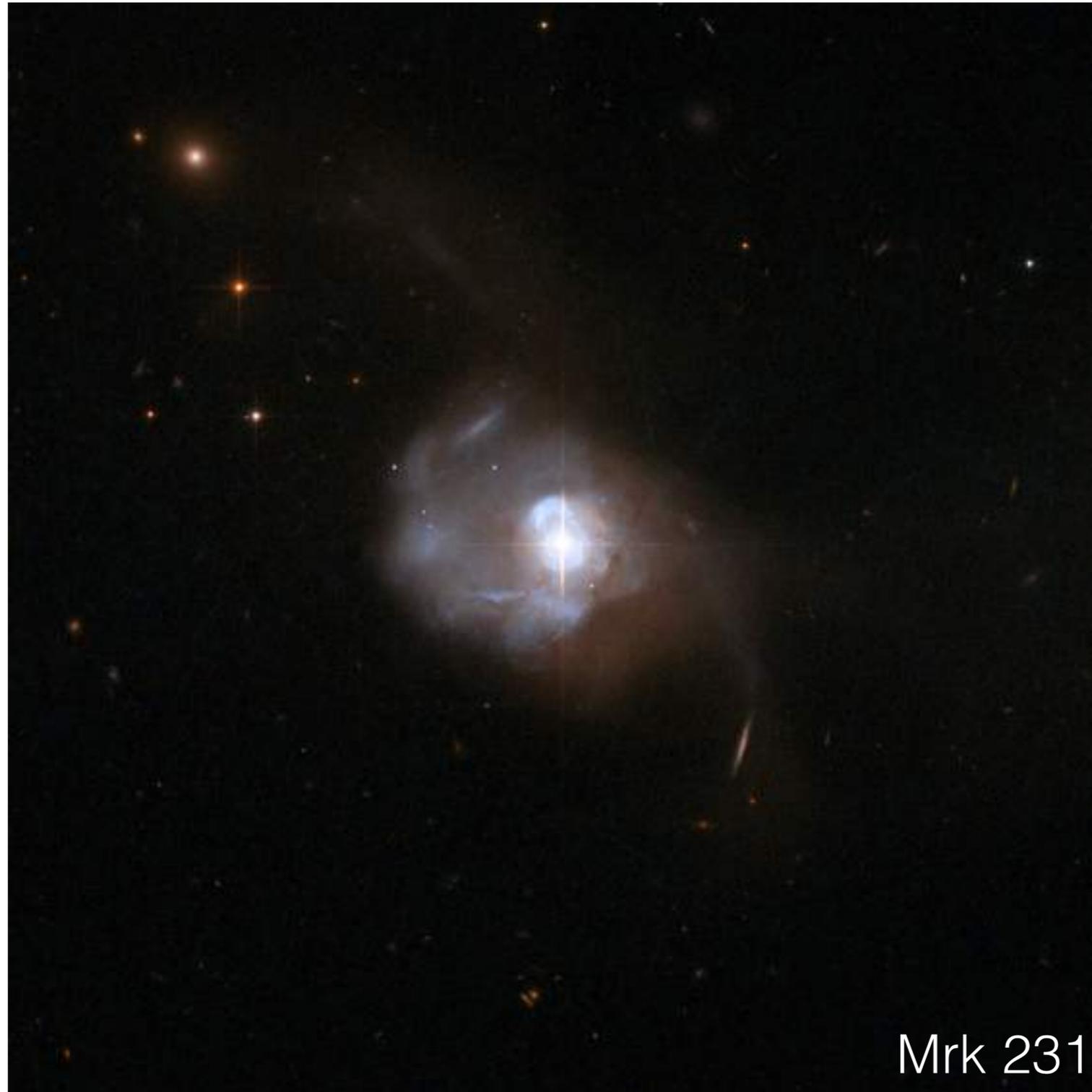
- ▶ what is dark matter?
- ▶ what is the observational evidence?

Other galaxies



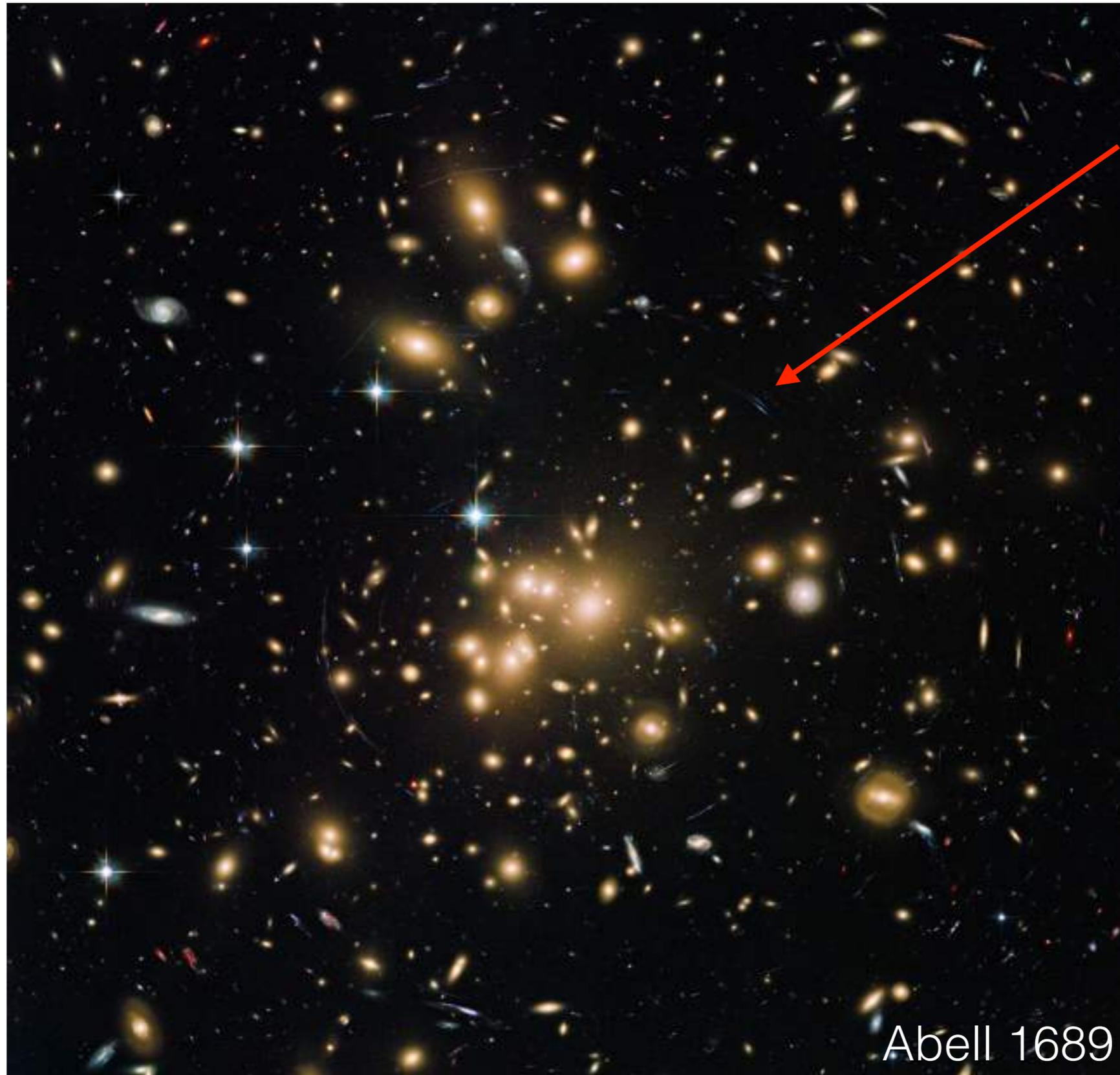
Hubble Space Telescope
Ultra-Deep Field

Active galactic nuclei



▶ accreting nuclear black holes

Groups and clusters of galaxies



lensing arcs

Abell 1689

The expanding Universe and dark energy

