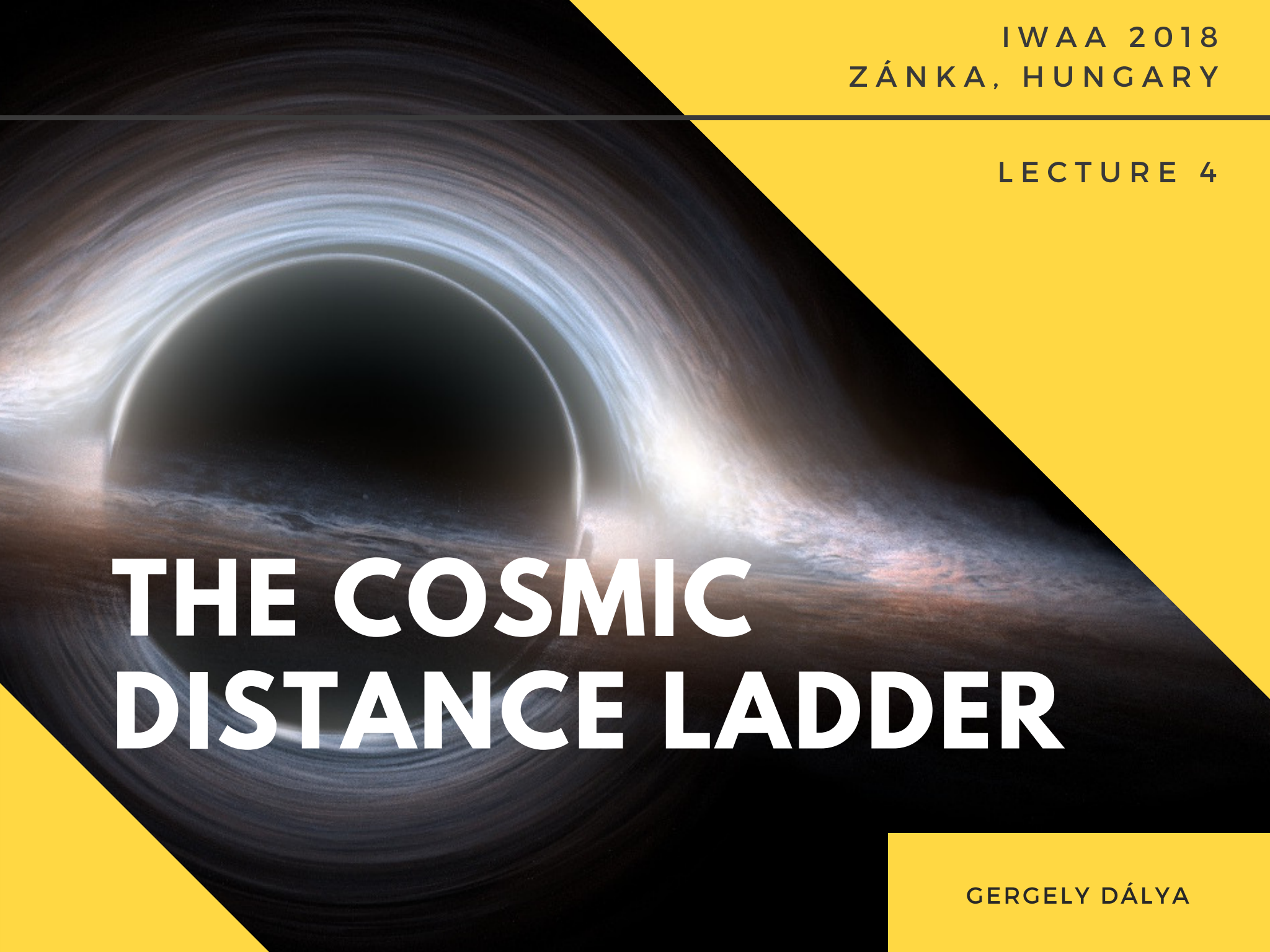
IWAA 2018
ZÁNKA, HUNGARY

LECTURE 4

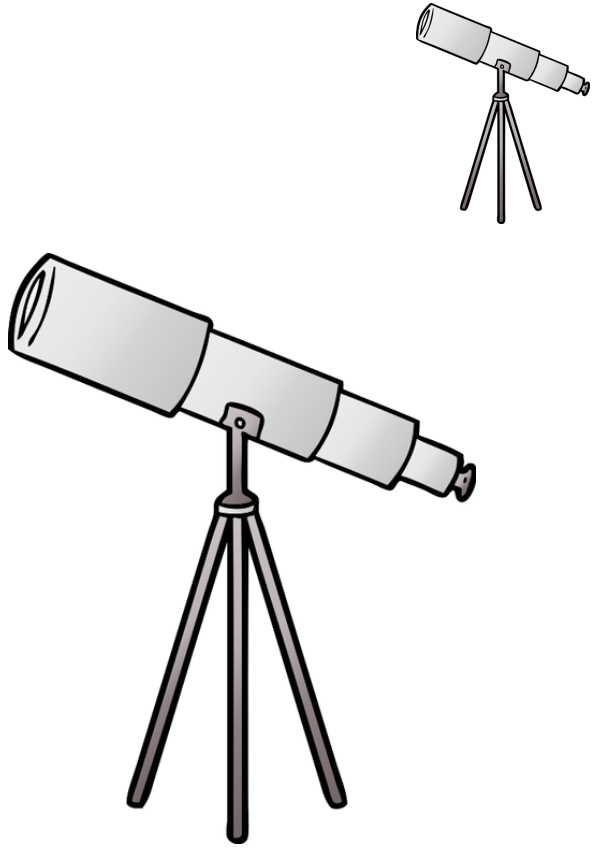


THE COSMIC DISTANCE LADDER

GERGELY DÁLYA

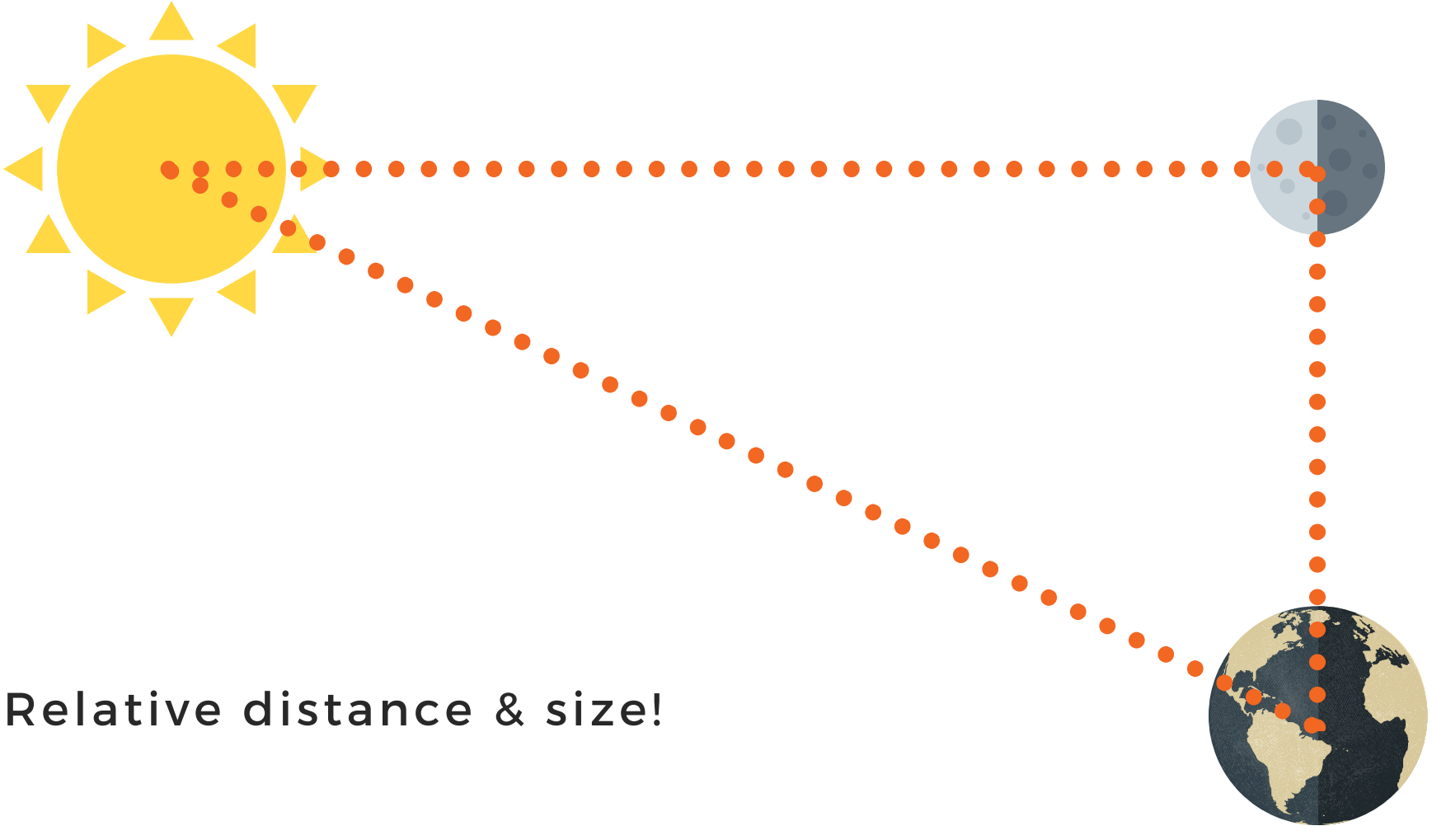
We know the size of objects

If its farther away, it seems to be smaller



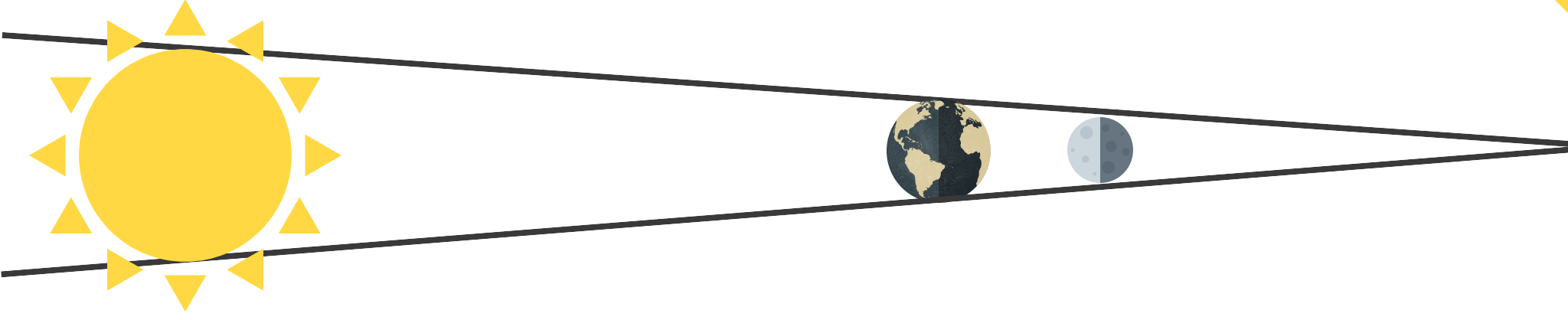
It can't be done in astronomy...

Aristarchus @ lunar dichotomy



Relative distance & size!

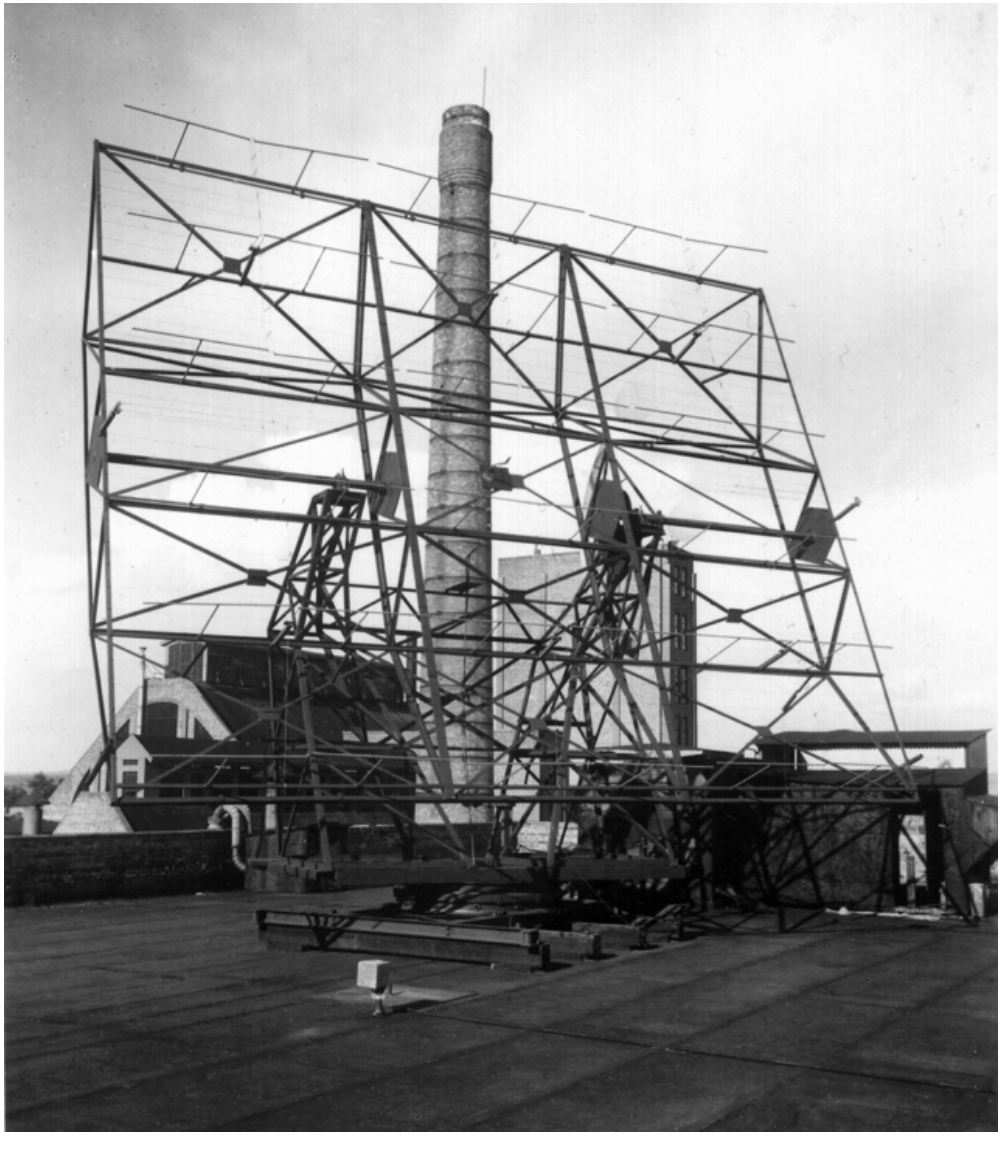
Aristarchus @ lunar eclipse

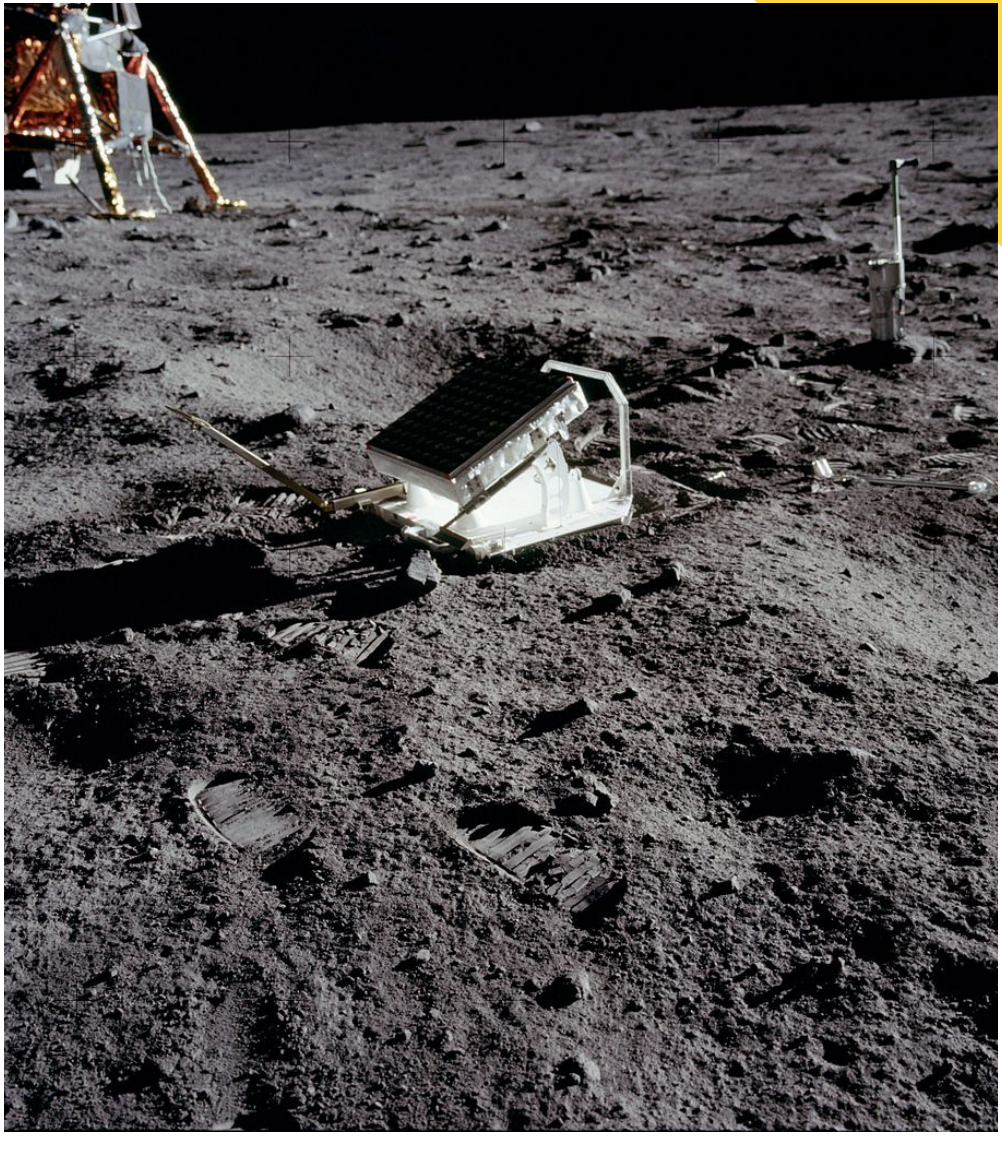


Earth is 3 times bigger than the Moon

Sun is bigger than the Earth: heliocentric model!

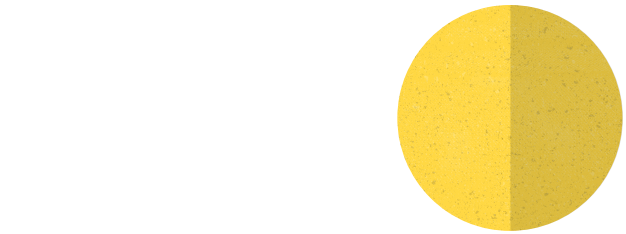
Moon radar: Zoltán Bay 1946; Laser ranging: Apollo 11

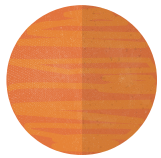


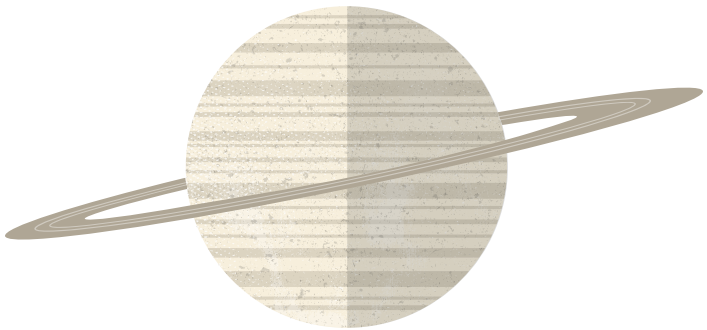


1 absolute + several relative measurements

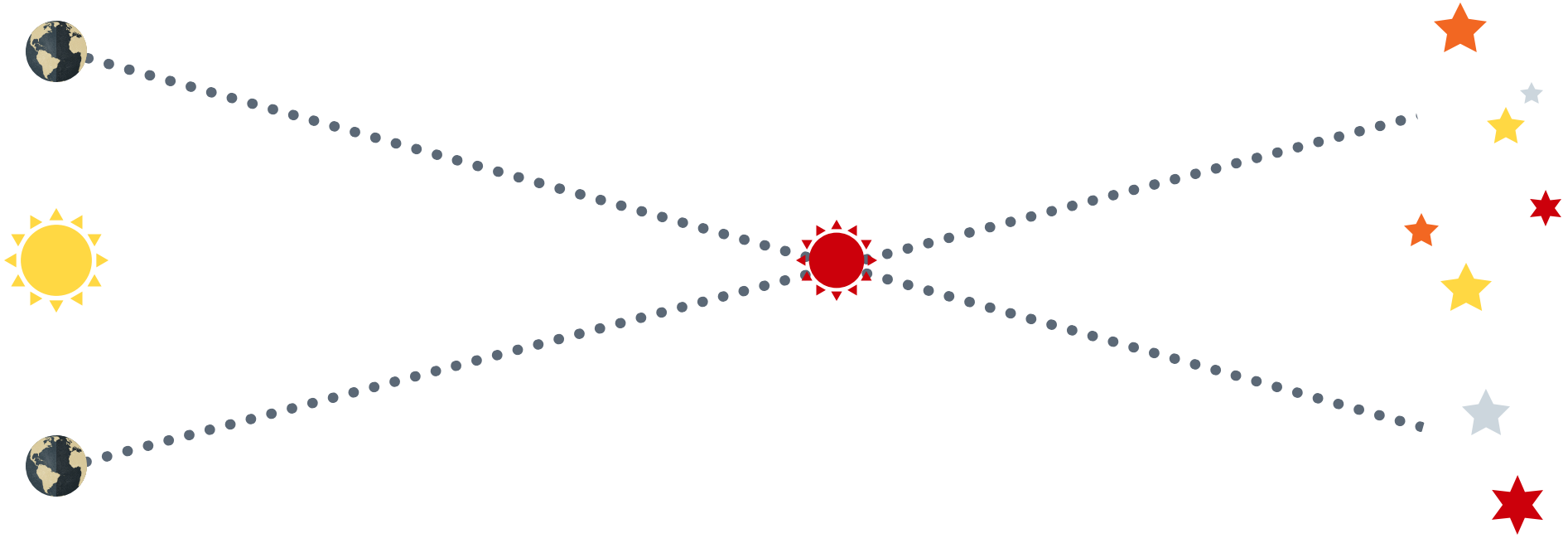
Planets? With Kepler's 3rd law.







Method of yearly parallax



Relative method: you've to know how big 1 AU is...

If only we knew the absolute brightness of objects...

Cepheids, RR Lyraes, SNe, ...

Period-Luminosity relation

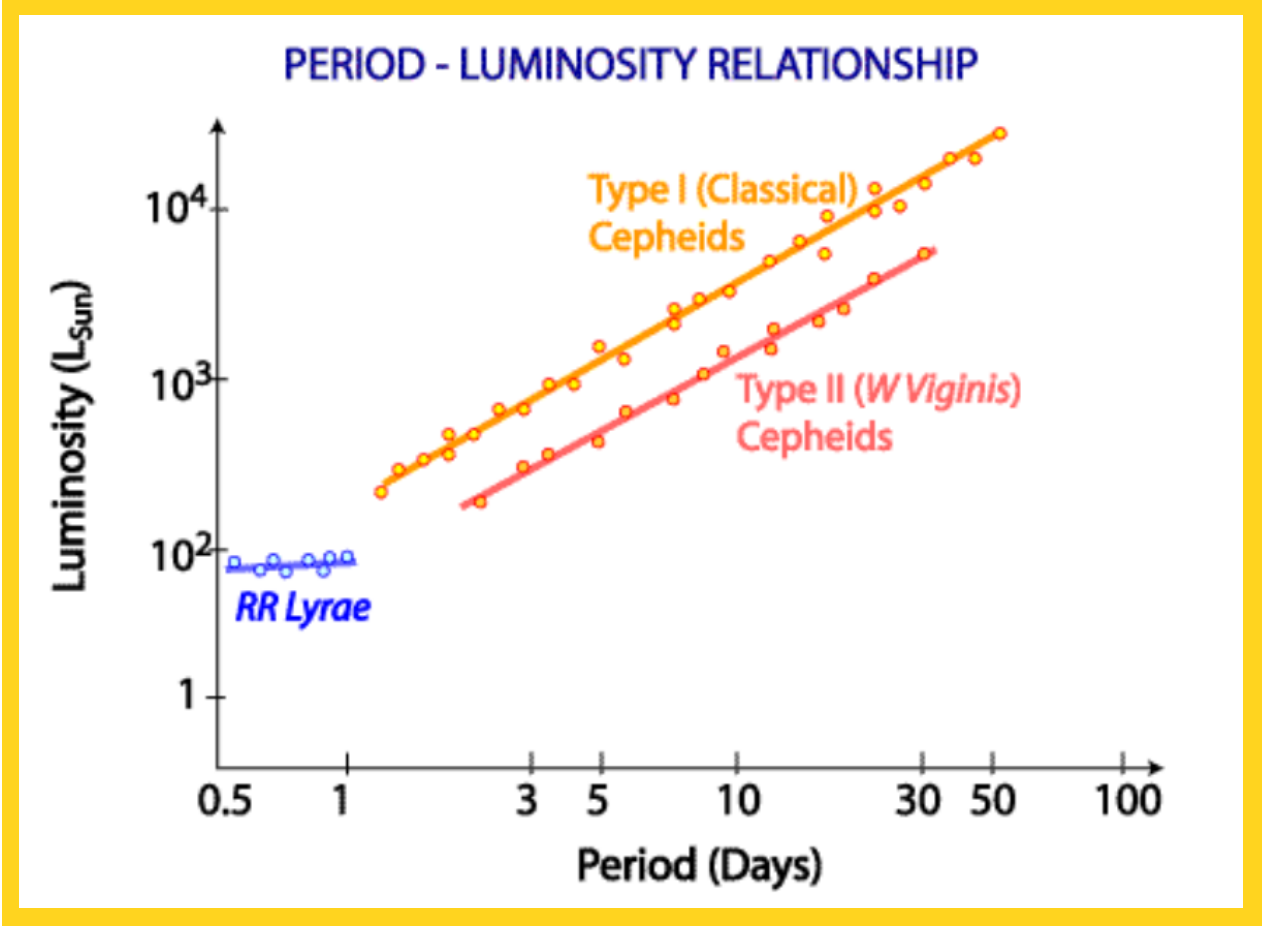
$$L \sim P^{\beta}$$

$$\log L = \beta \log P + C$$

$$M = \beta \log P + C'$$

cf. IOAA 2017, D1 (depends on color as well)

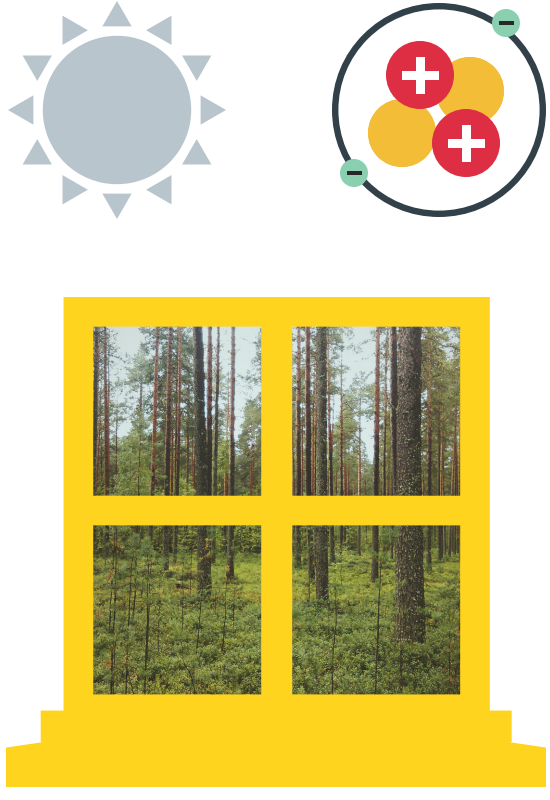
Period-Luminosity relation

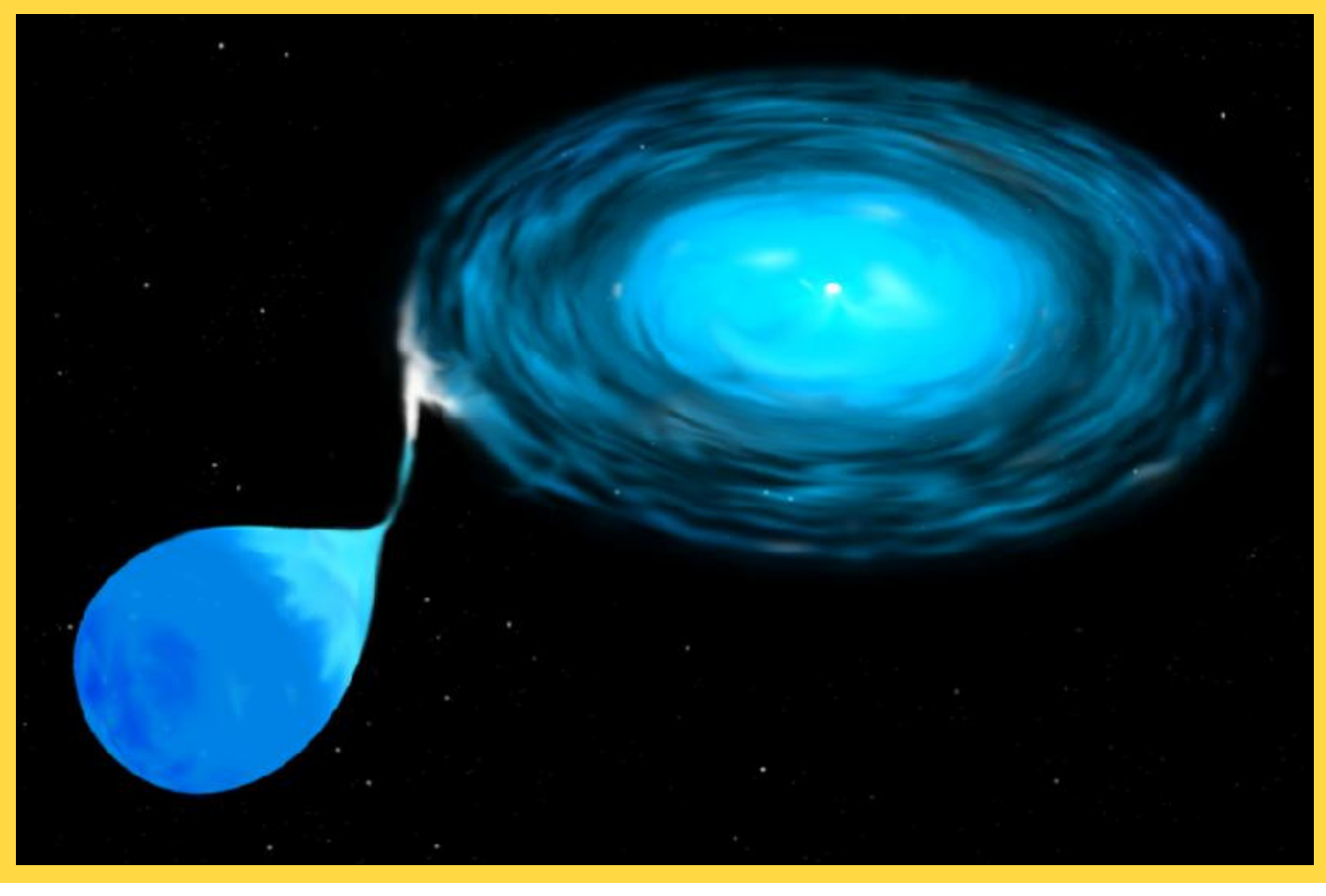


Either use log scale or log P!

$$m - M = -5 + 5 \log d$$

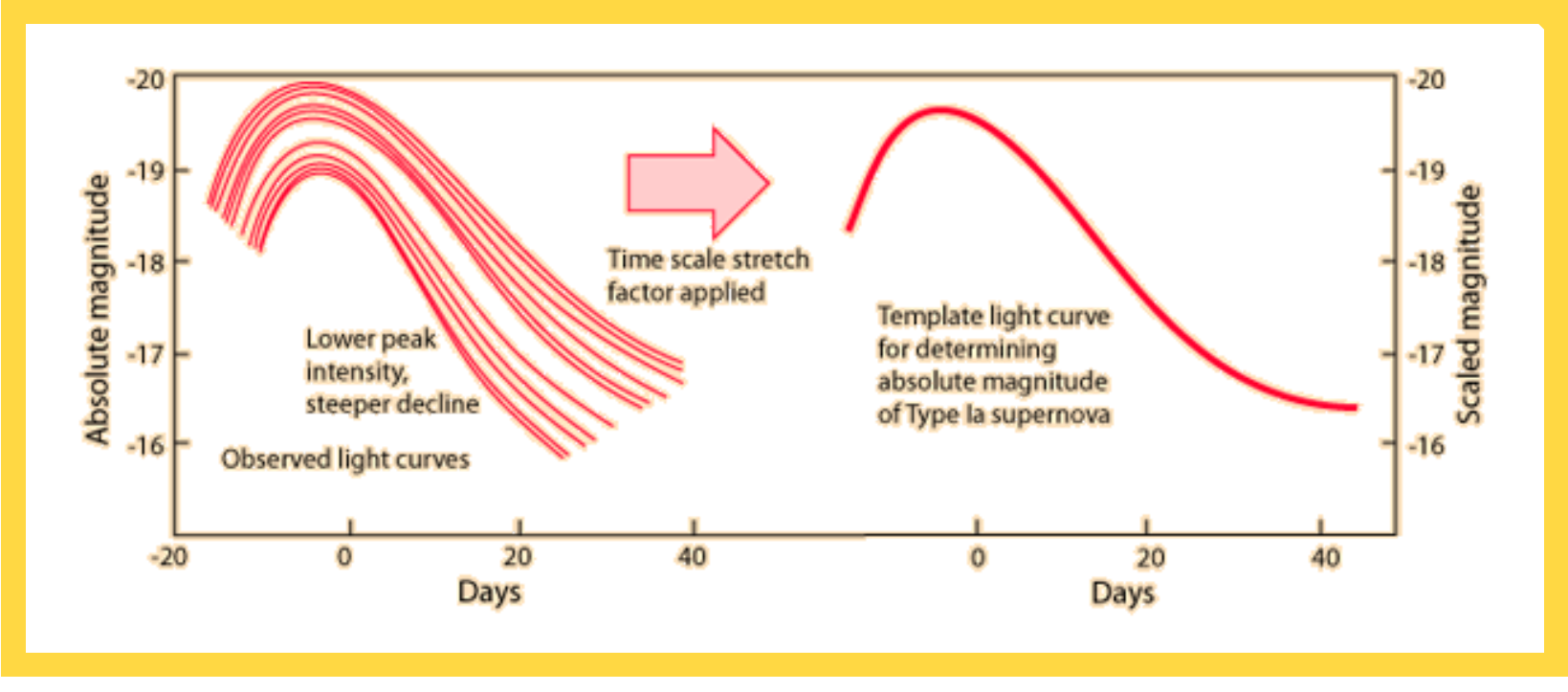
KAPPA-MECHANISM





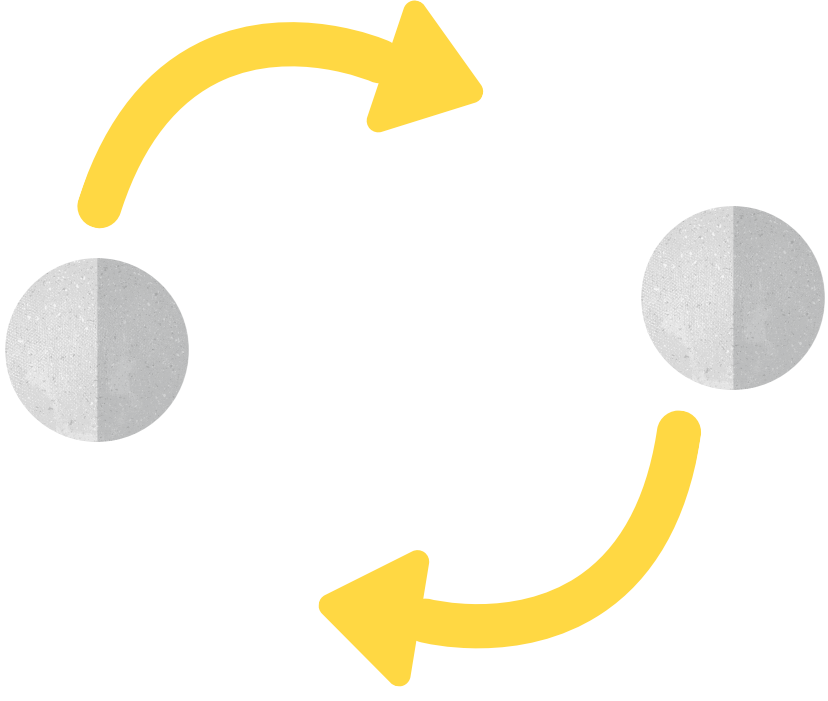
Chandrasekhar limit: 1.44 solar masses

Not quite as simple...

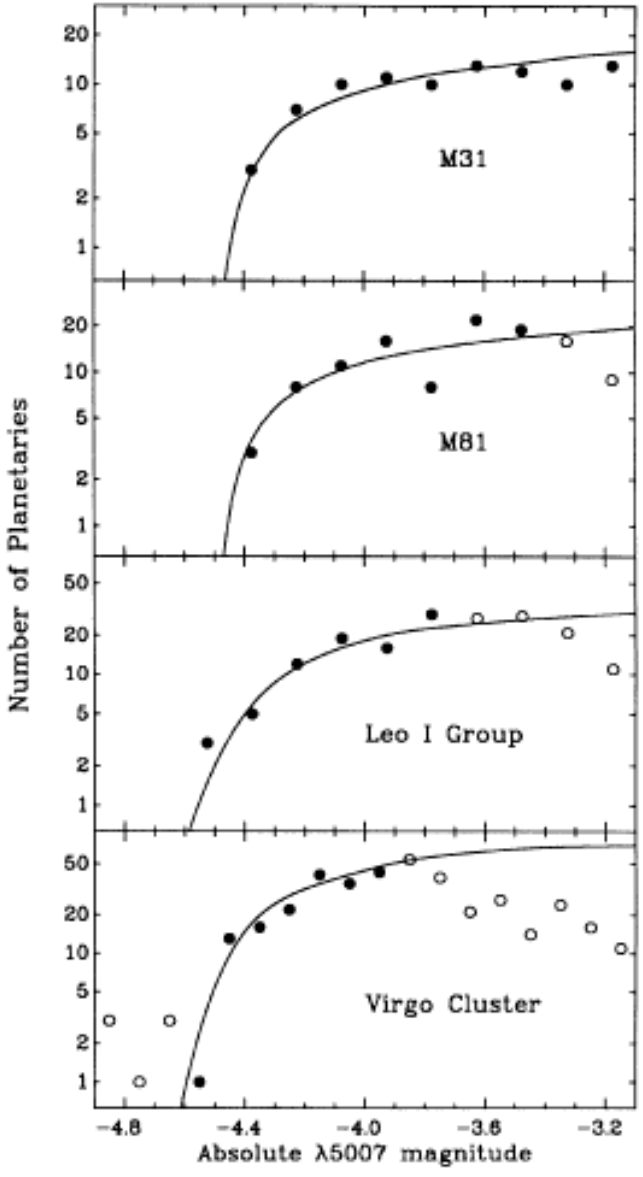


$$\langle M_B \rangle \simeq \langle M_V \rangle \simeq -19.3^{\mathrm{m}} \pm 0.03^{\mathrm{m}}$$

Super-Chandrasekhar mass SNe



Challenges the standard candle picture...



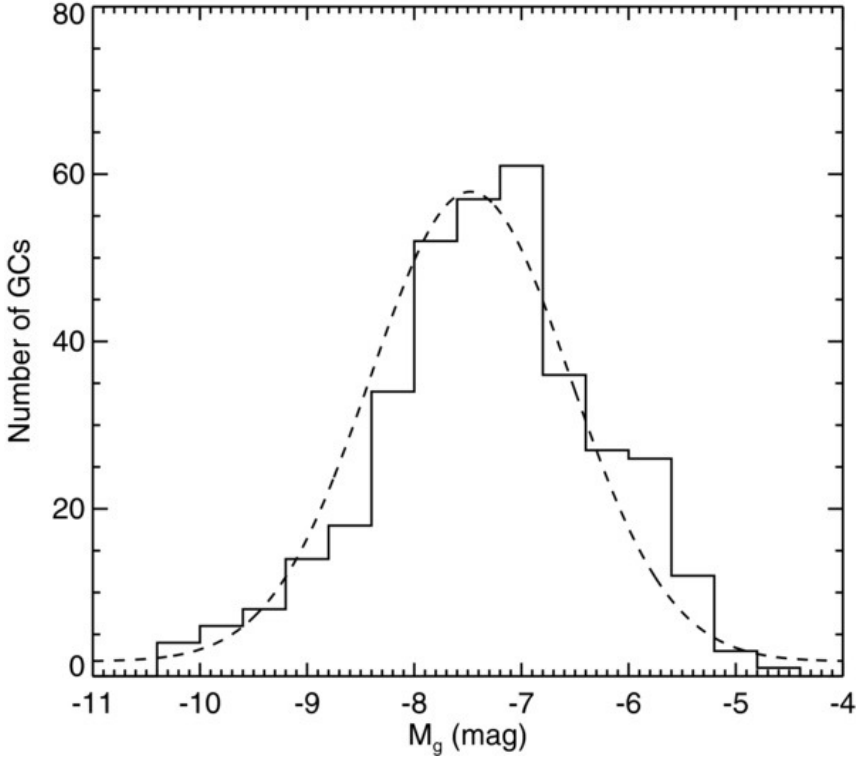
Planetary nebula luminosity function

[OIII] 500.7 nm line

$$N(M) \sim e^{0.307M}(1 - e^{3(M^* - M)})$$

Works for all types of galaxies

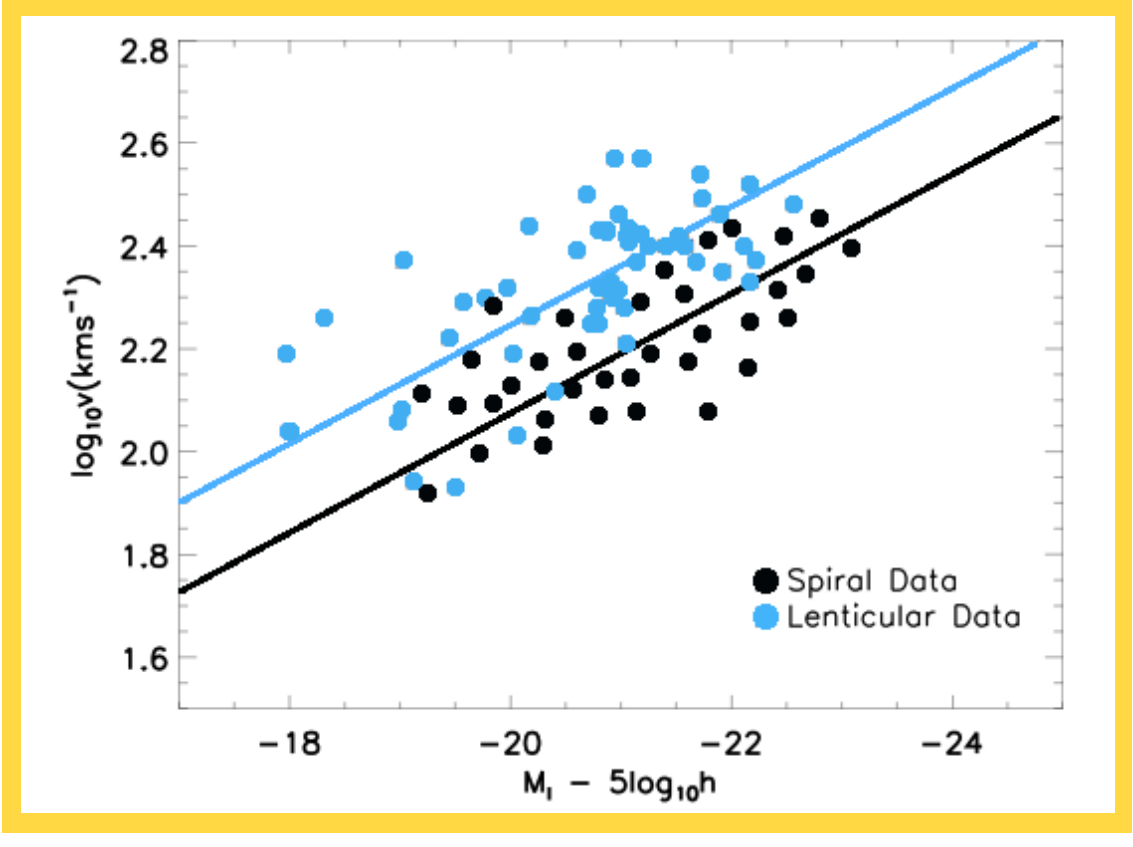
Globular cluster luminosity function

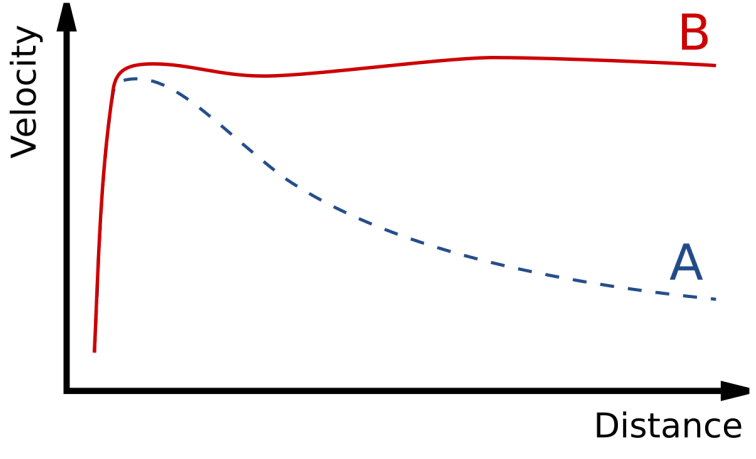


$$\Phi(m) = Ae^{(m-m_0)^2/2\sigma^2}$$

Does not depend on properties of host galaxy

Rotational velocity ~ Absolute brightness

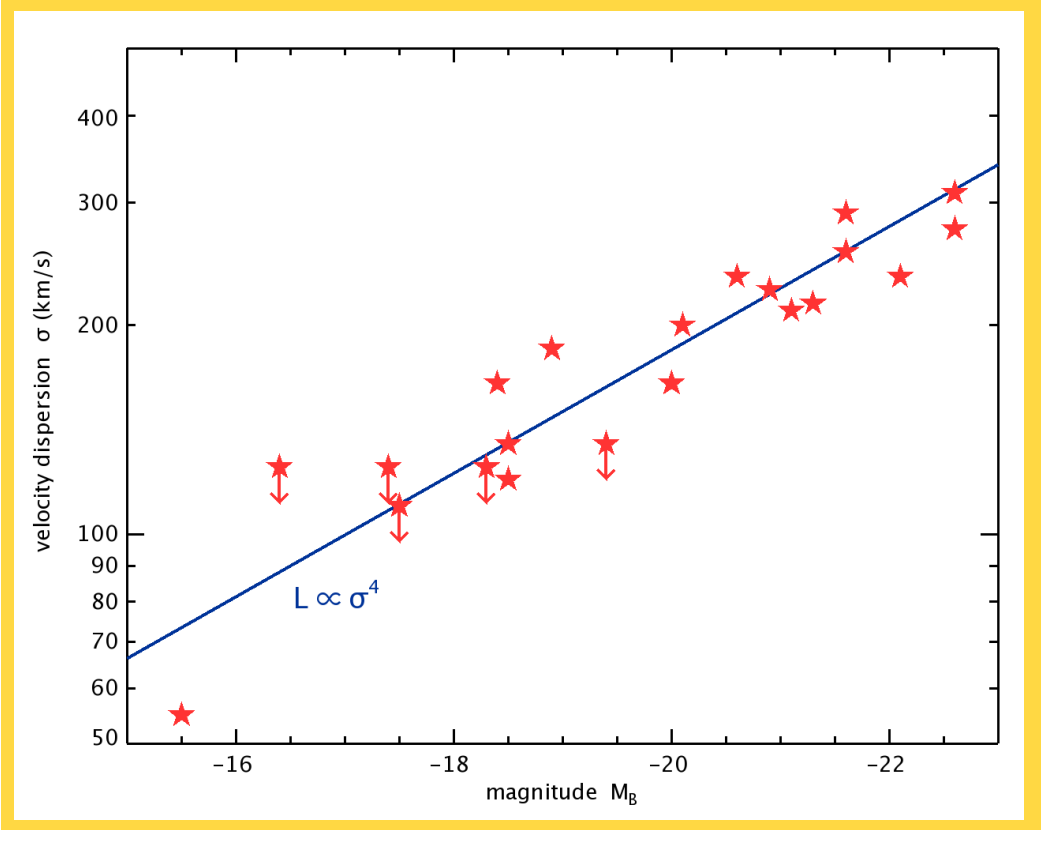




For spirals & lenticulars only!

FABER-JACKSON RELATION

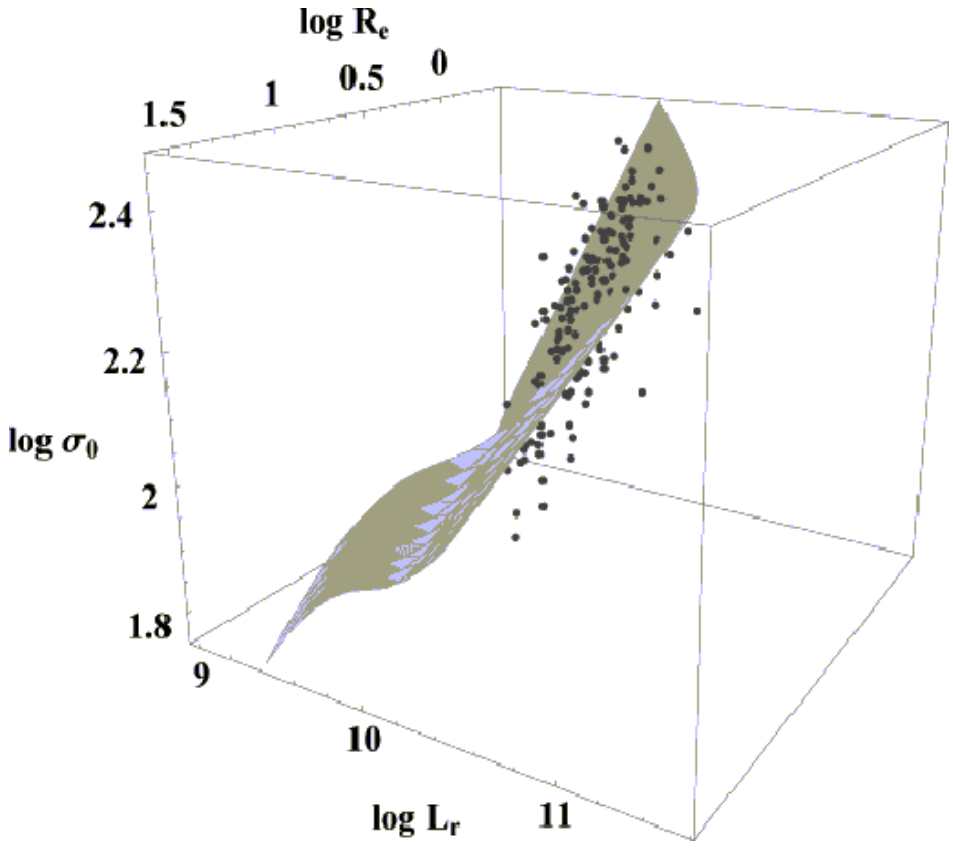
Stellar vel. dispersion ~ Absolute brightness



For ellipticals only!

Let's take 3 properties, e.g.:

- Velocity dispersion
- Surface brightness
- Radius



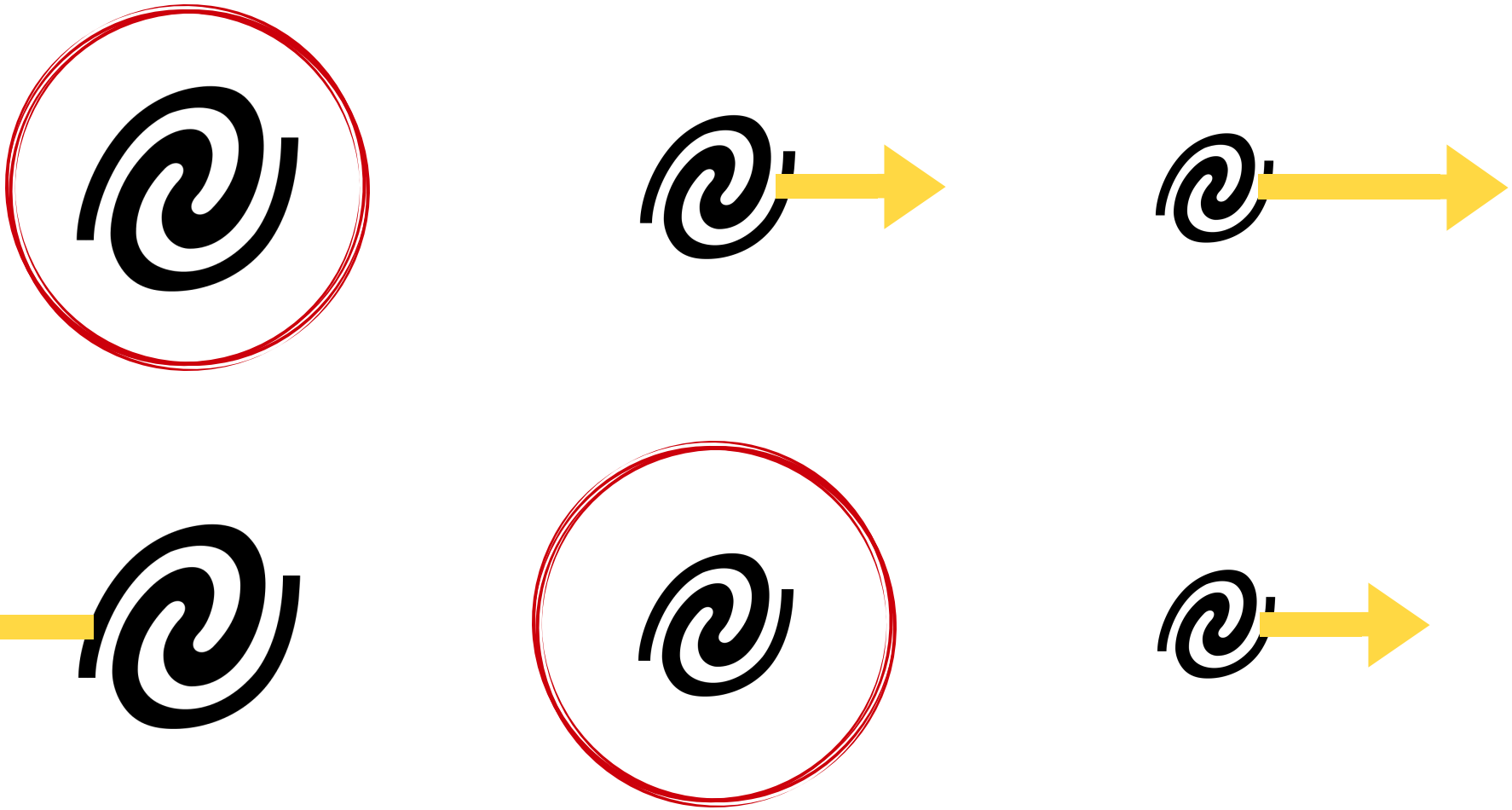
$$L \sim \sigma^4 \Sigma^{-1}$$

Calculated + measured radii → Distance

$$v = H_0 D$$

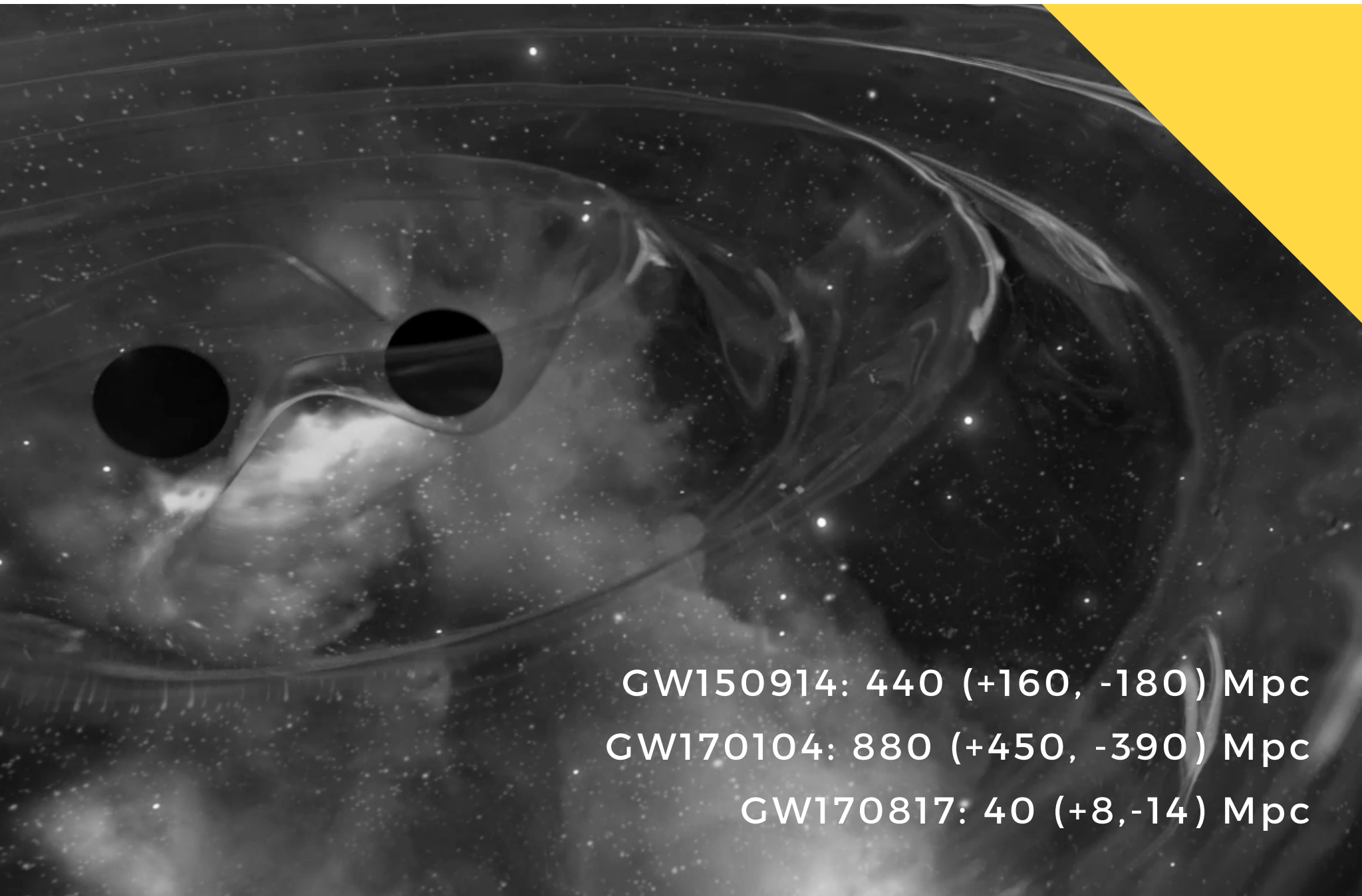
EVERY GALAXY MOVES AWAY FROM US... ARE WE THE CENTER OF THE UNIVERSE?

IT IS THE SAME FROM EVERYWHERE:




POLICE

STANDARD SIRENS



GW150914: 440 (+160, -180) Mpc

GW170104: 880 (+450, -390) Mpc

GW170817: 40 (+8,-14) Mpc

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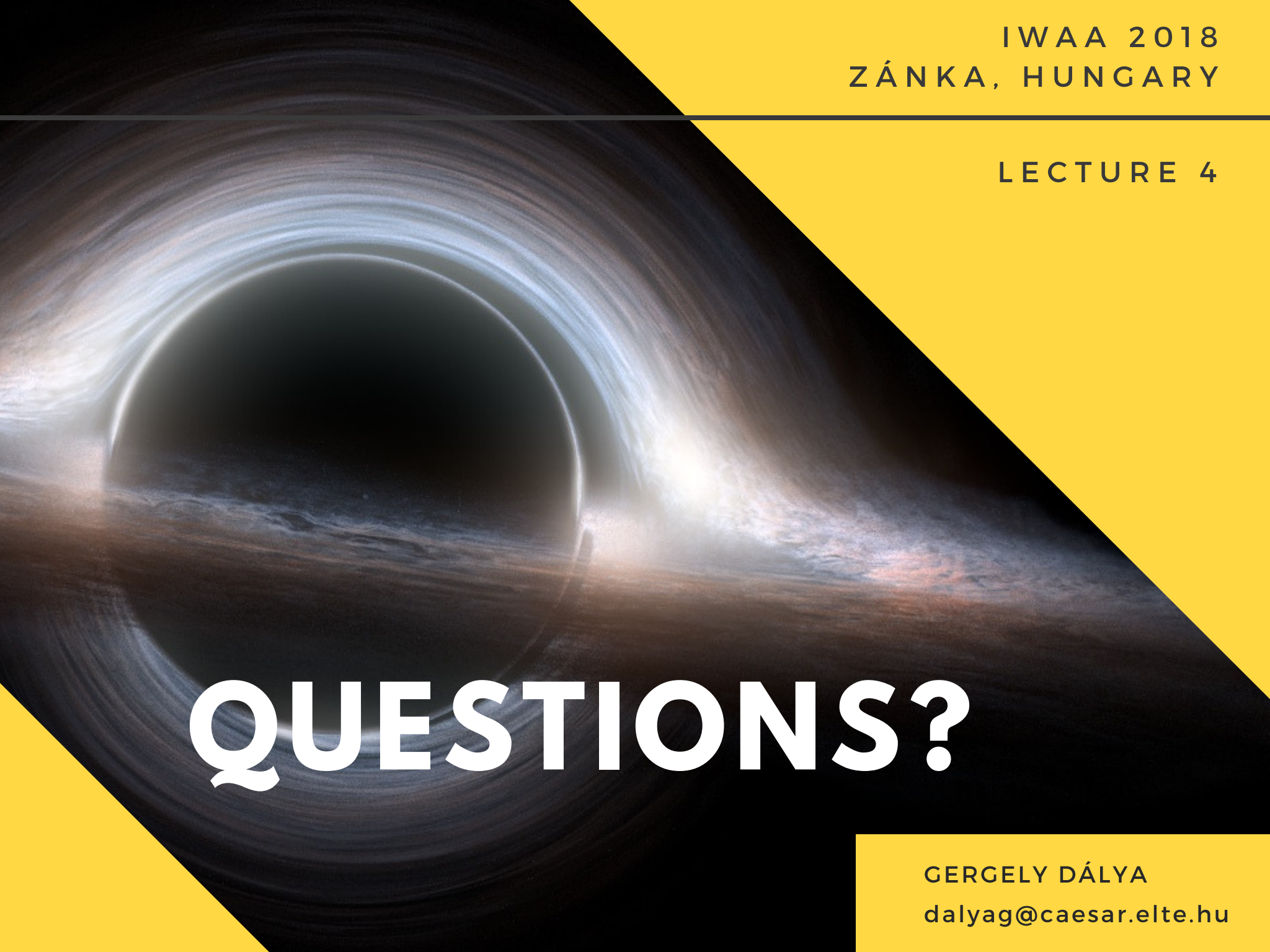

QUESTIONS?

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