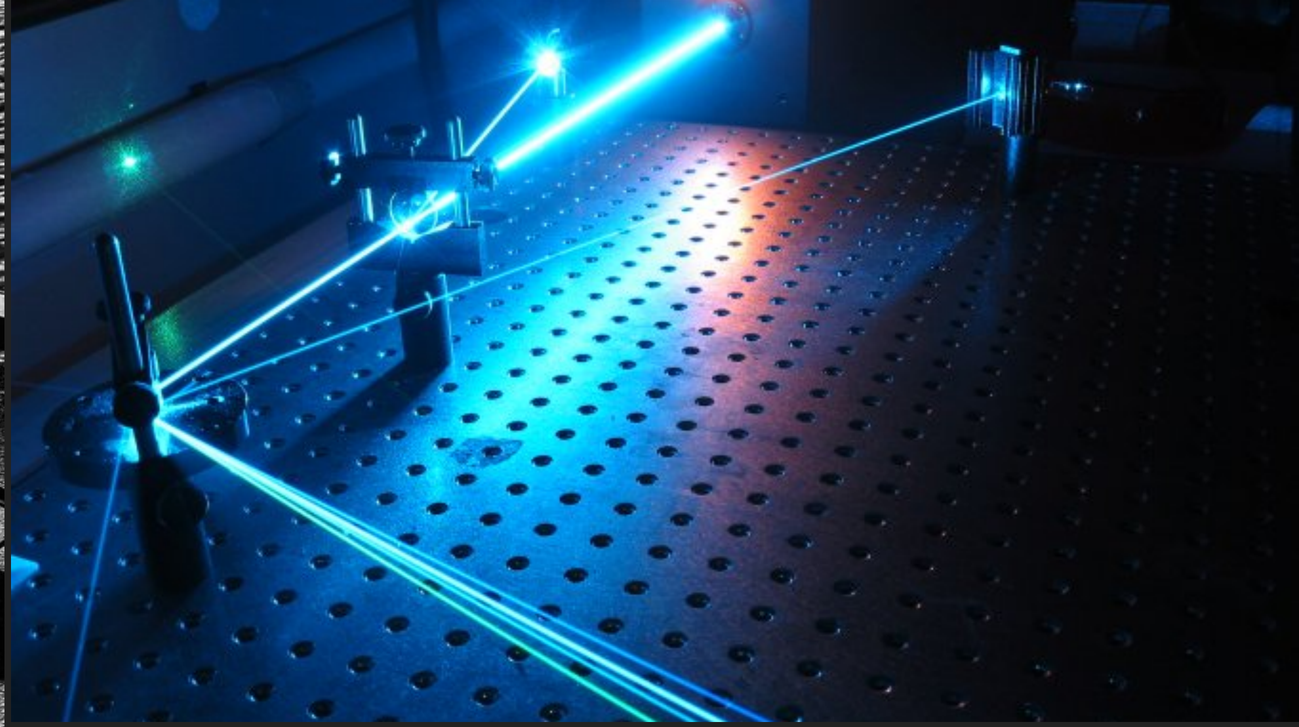
GRAVITATIONAL LENSING: SPACETIME UNDER THE INFLUENCE (OF GRAVITY)

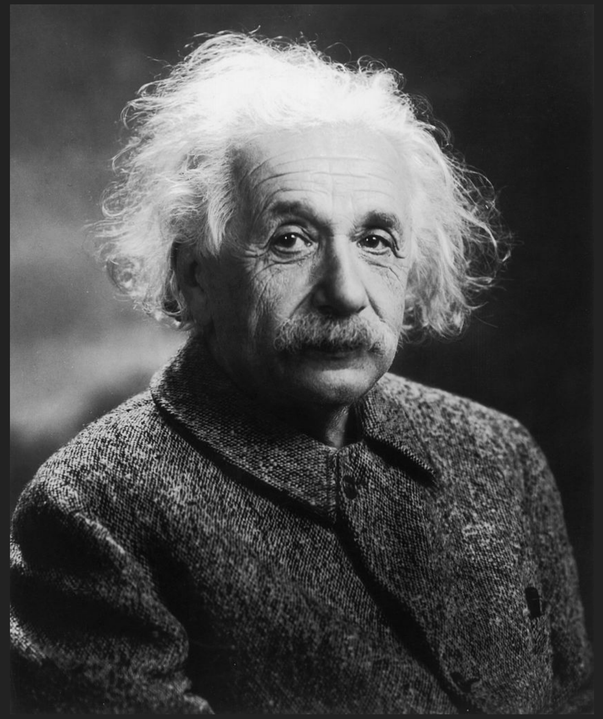
UNIVERSITY OF BIRMINGHAM ASTRONOMY IN THE CITY VIRTUAL EVENT —
3 FEB 2021

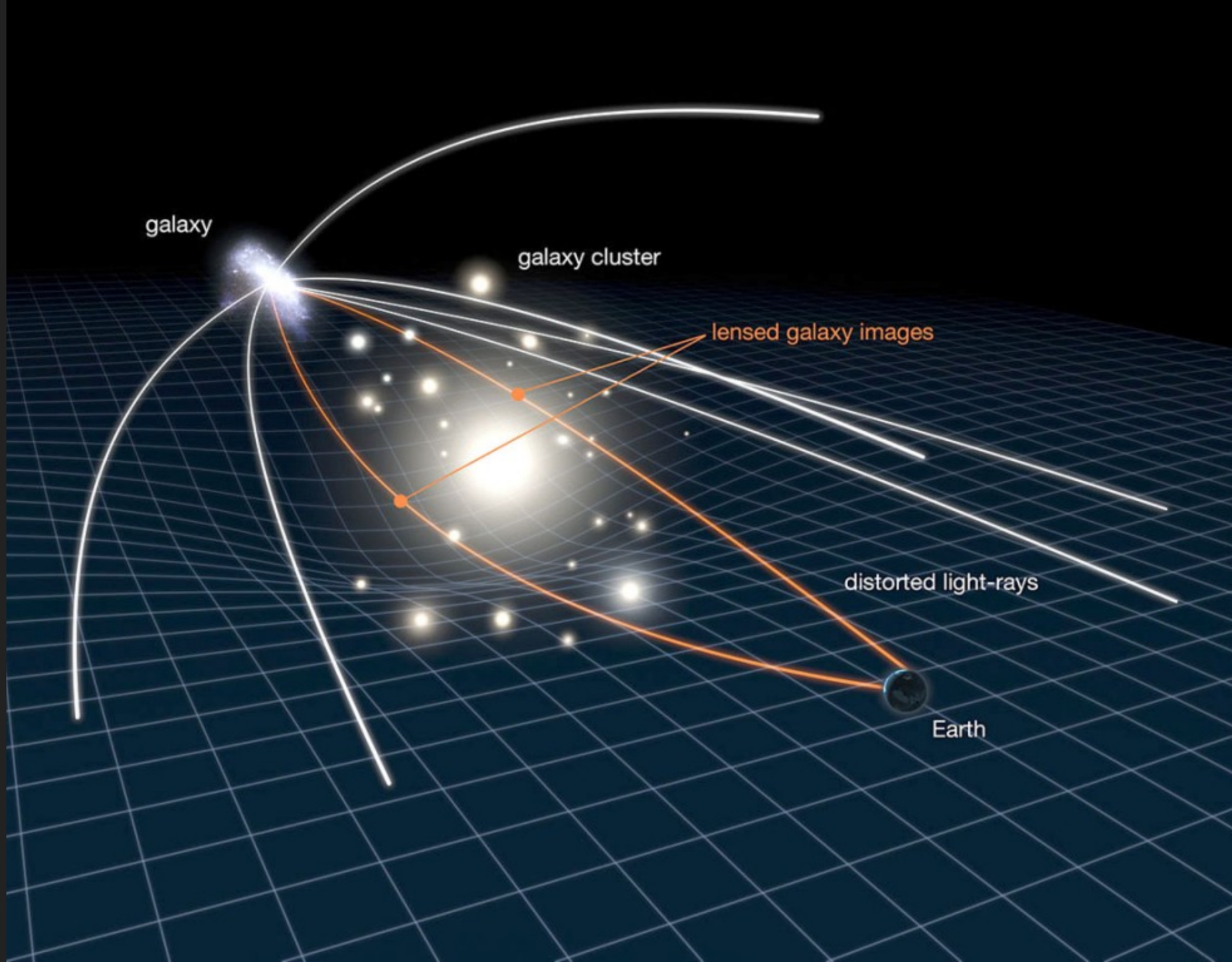
DAN RYCZANOWSKI



LEFT ALONE, LIGHT TRAVELS IN PERFECTLY STRAIGHT LINES

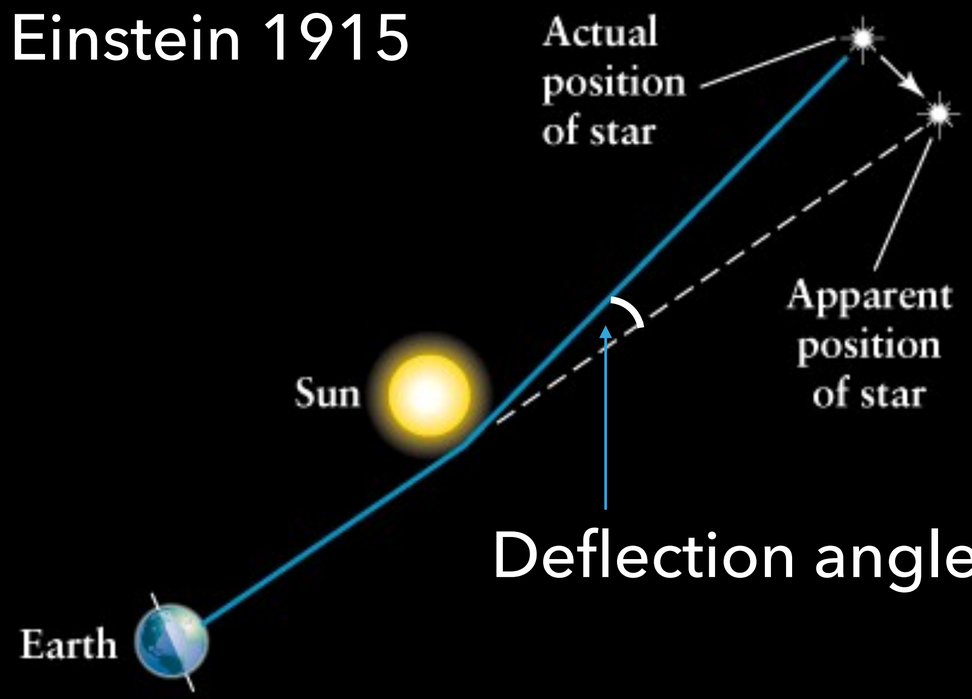
GRAVITATIONAL LENSING — MASS BENDS LIGHT



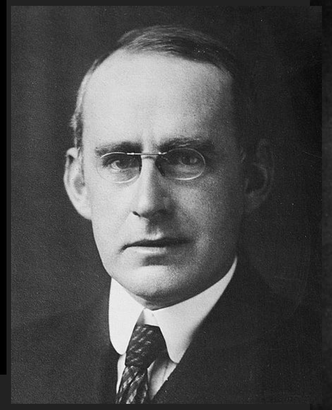


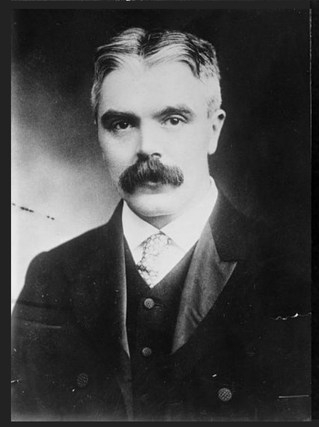
THE DEFLECTION OF LIGHT

Idea: Einstein 1915



Deflection angle

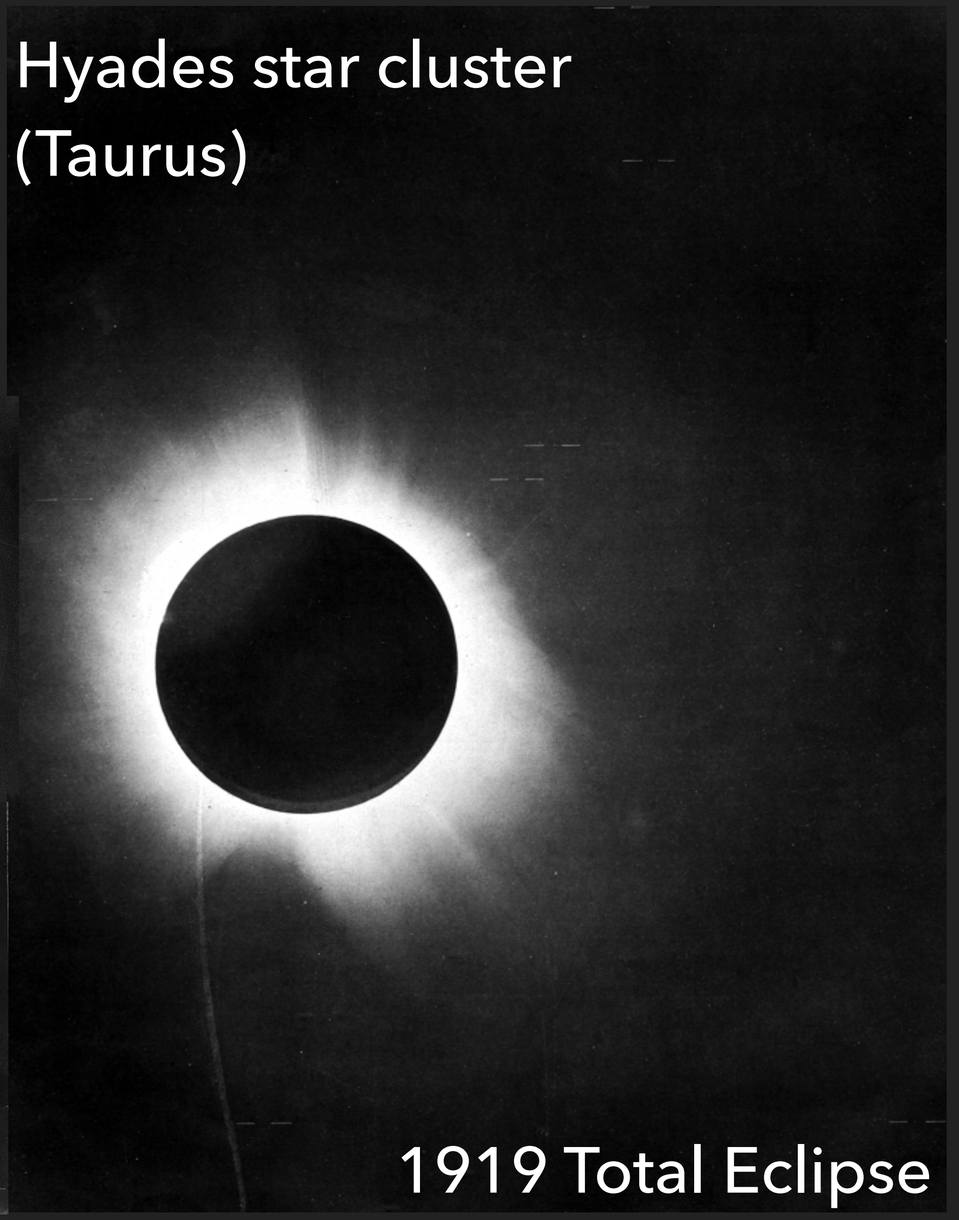




Sir Arthur Eddington (top)

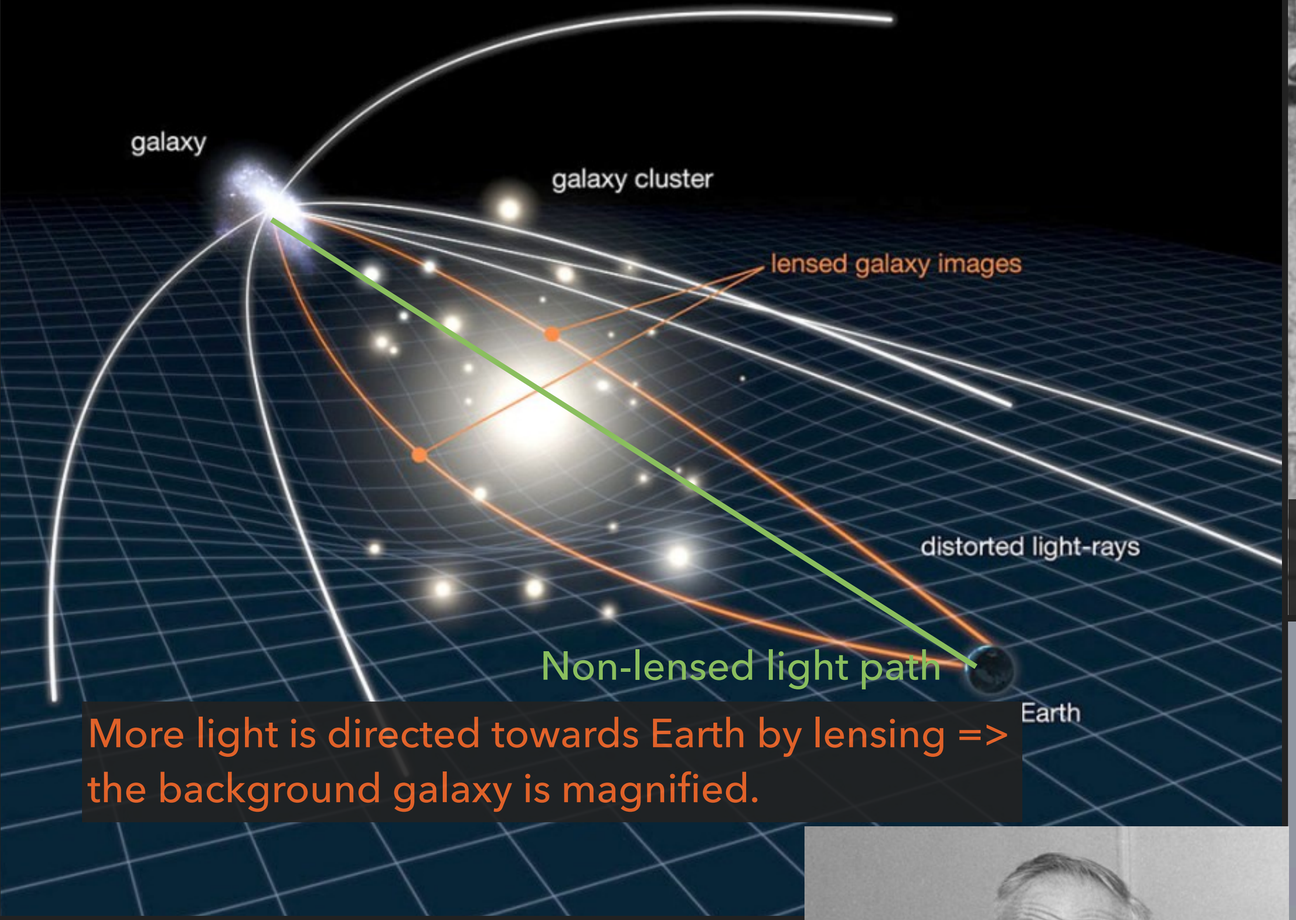
Sir Frank Dyson (bottom)

Hyades star cluster (Taurus)

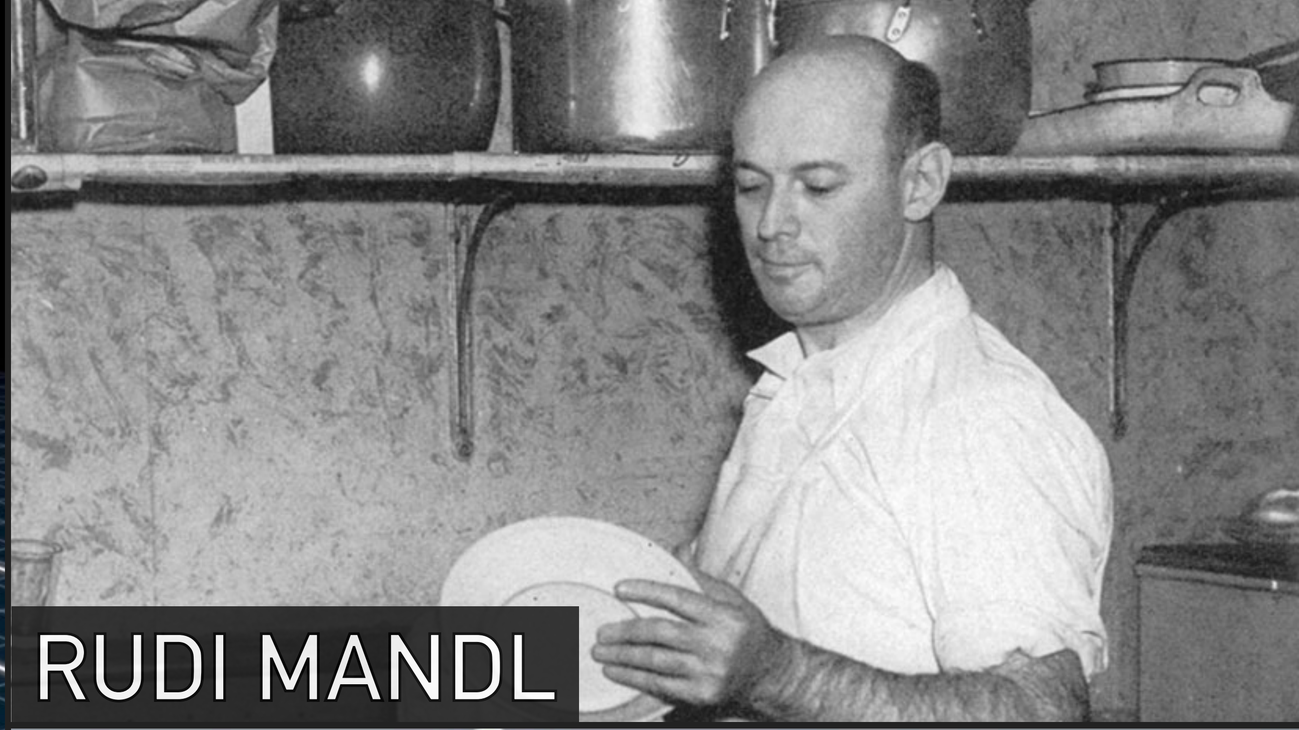


1919 Total Eclipse

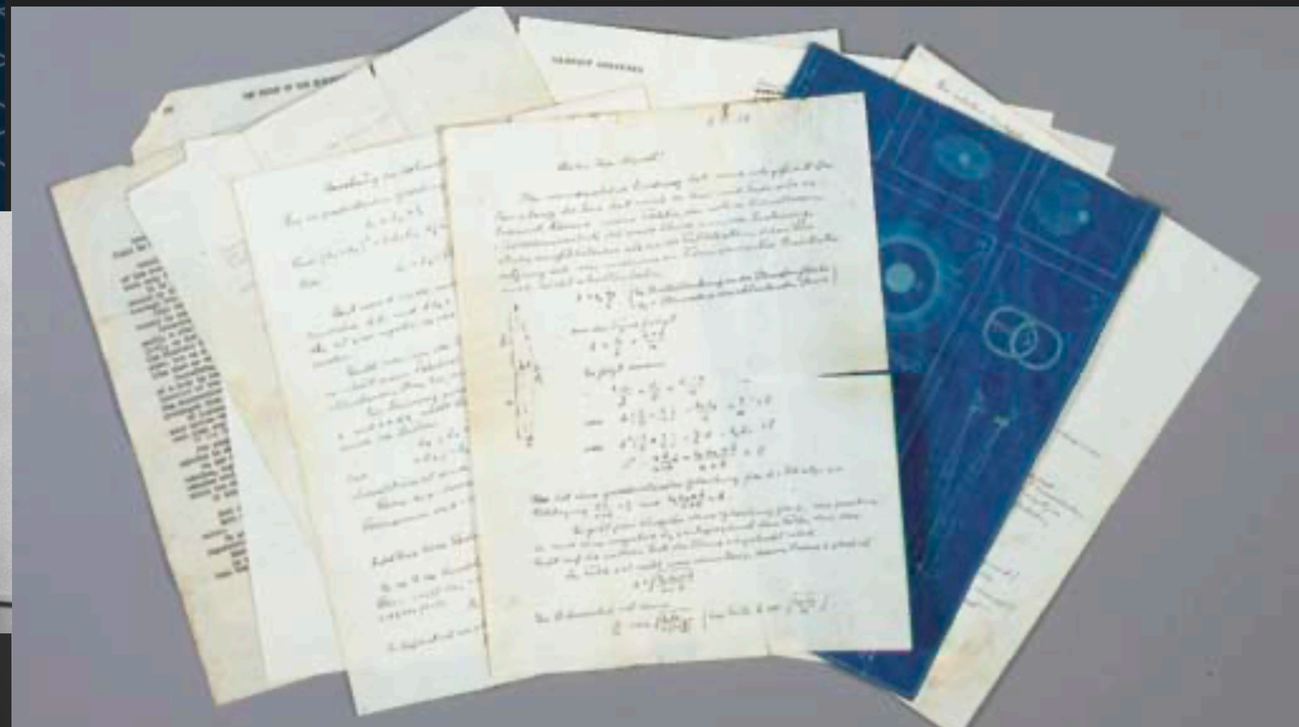
EXTENSION OF THEORY: STRONG LENSING

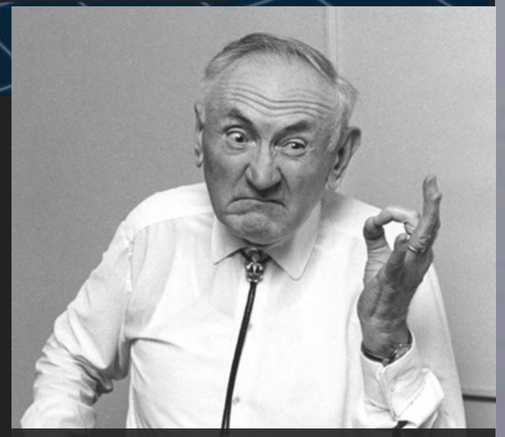


More light is directed towards Earth by lensing => the background galaxy is magnified.



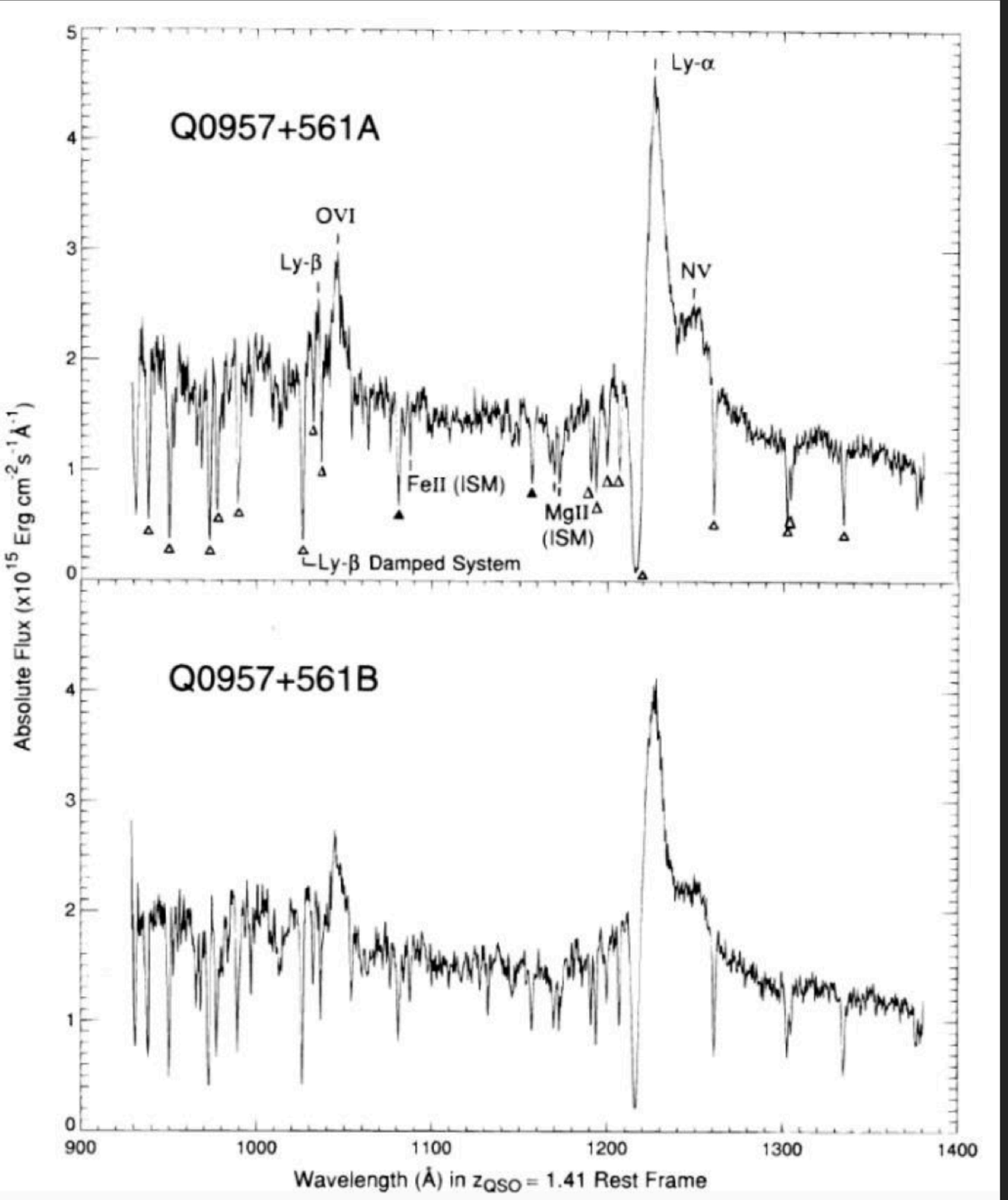
RUDI MANDL





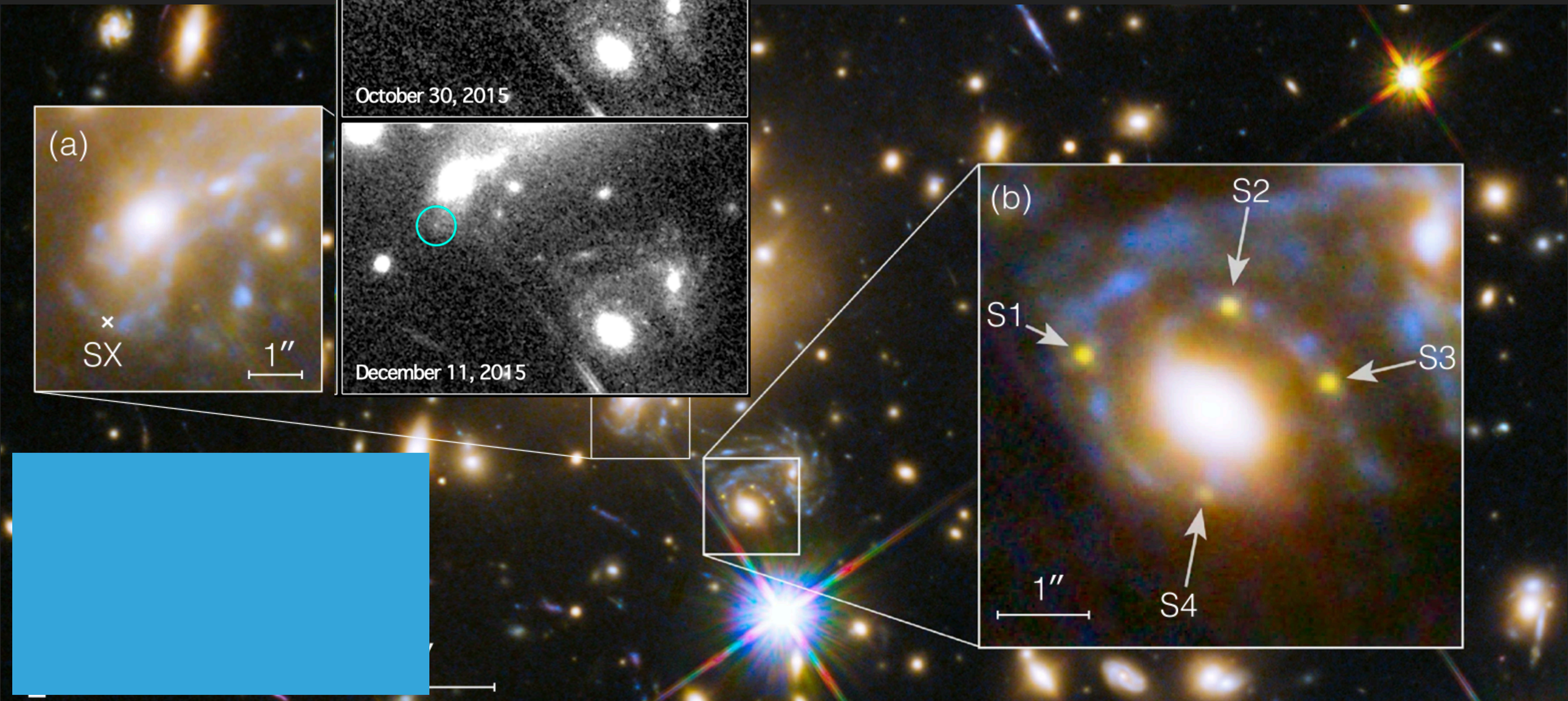
FRITZ ZWICKY

THE FIRST STRONGLY-LENSED OBJECT: QSO-0957



Walsh et al. (1979)

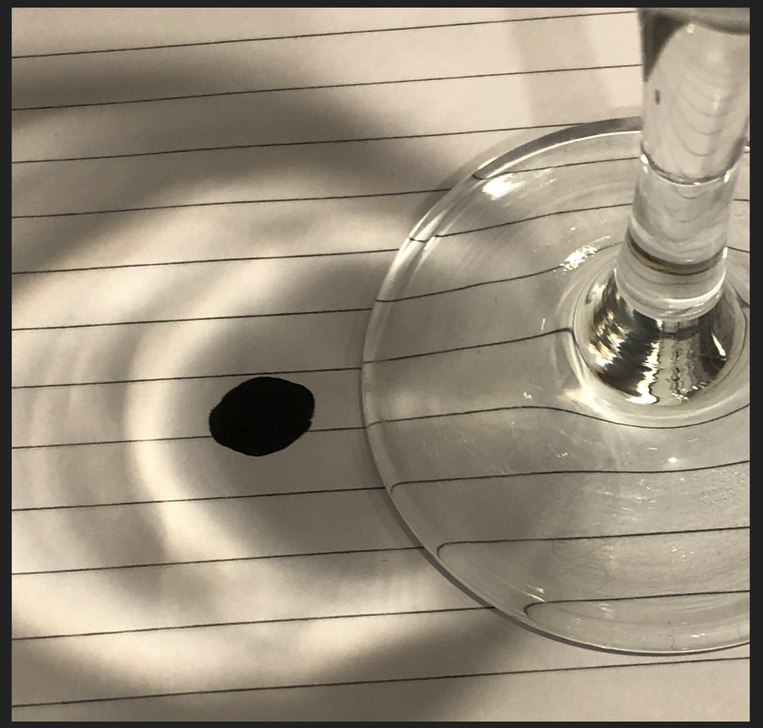
THE FIRST STRONGLY LENSED SUPERNOVA: SN REFSDAL

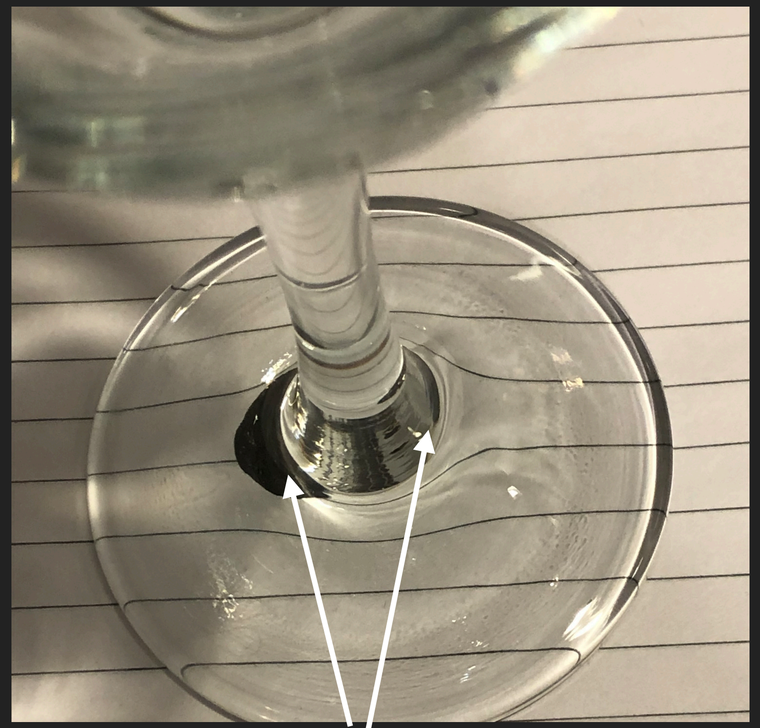


A370: DRAMATIC GALAXY CLUSTER LENS

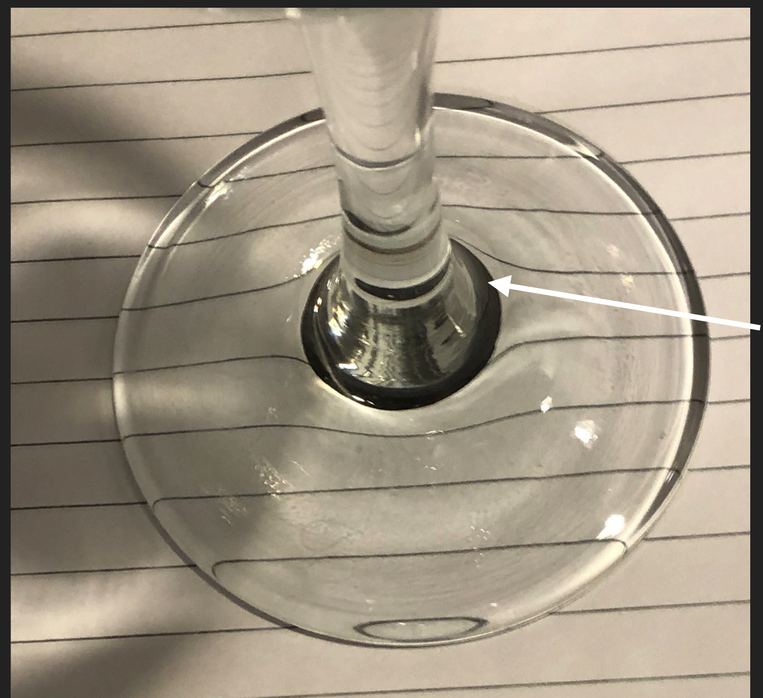
Grillo et al. (2018)

LRG 3-757: A NEAR-COMPLETE ‘EINSTEIN RING’





Distorted images



“Winestein” Ring
(I’m not sorry)

LENSING AROUND A BLACK HOLE

Image of the disk's far side

The black hole's gravitational field alters the path of light from the far side of the disk, producing this part of the image.

Photon ring

A ring of light composed of multiple distorted images of the disk. The light making up these images has orbited the black hole two, three or even more times before escaping to us. They become thinner and fainter closer to the black hole.

Black hole shadow

This is an area roughly twice the size of the event horizon — the black hole's point of no return — that is formed by its gravitational lensing and capture of light rays.

Doppler beaming

Light from glowing gas in the accretion disk is brighter on the side where material is moving toward us, fainter on the side where it's moving away from us.

Accretion disk

The hot, thin, rotating disk formed by matter slowly spiraling toward the black hole.

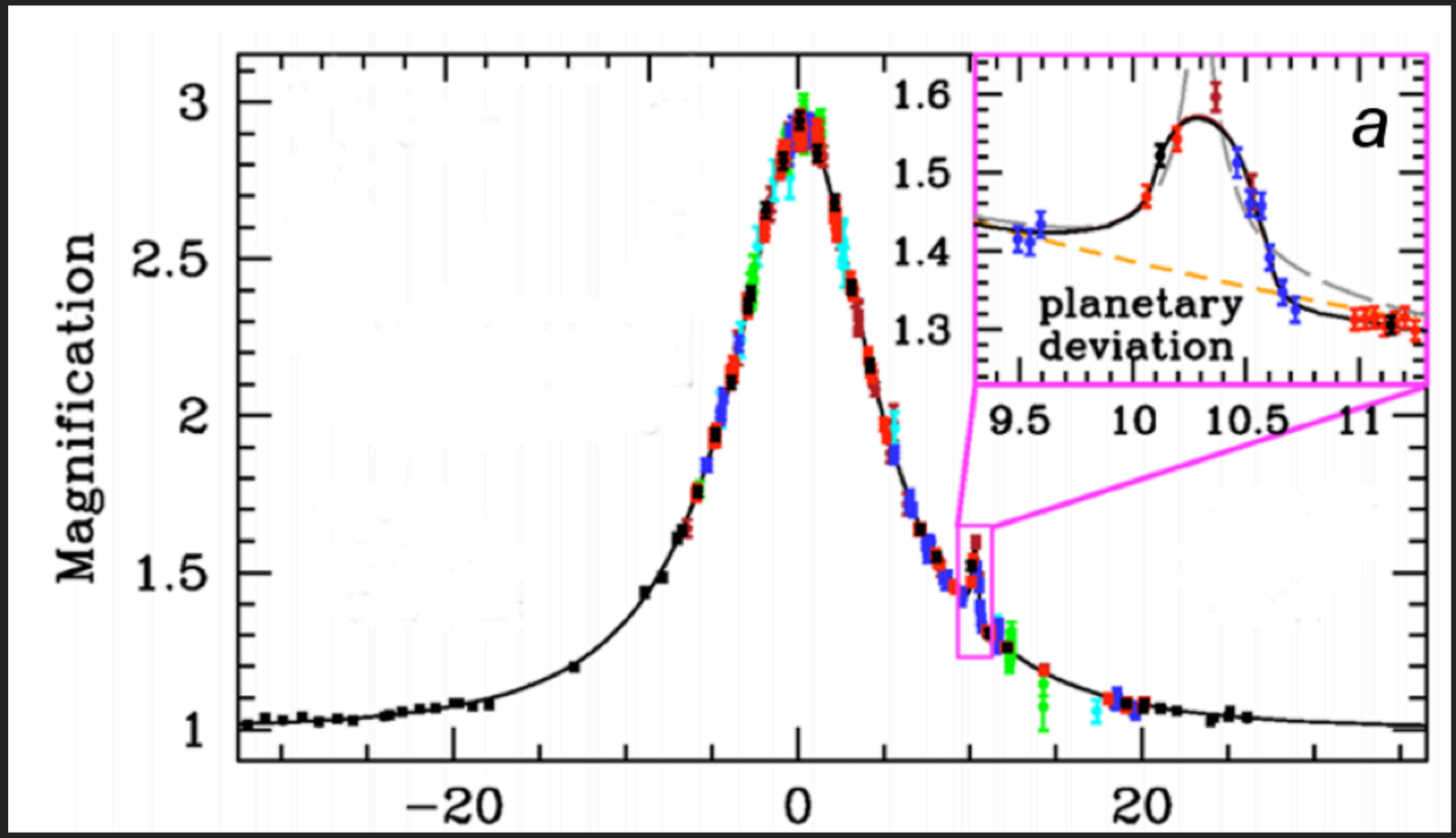
Image of the disk's underside

Light rays from beneath the far side of the disk are gravitationally "lensed" to produce this part of the image.

2019 EHT Image of M87

DETECTION OF AN EXOPLANET VIA LENSING

- Star lensed by another star
- Exoplanet observed orbiting lens star



Beaulieu et al. (2006)