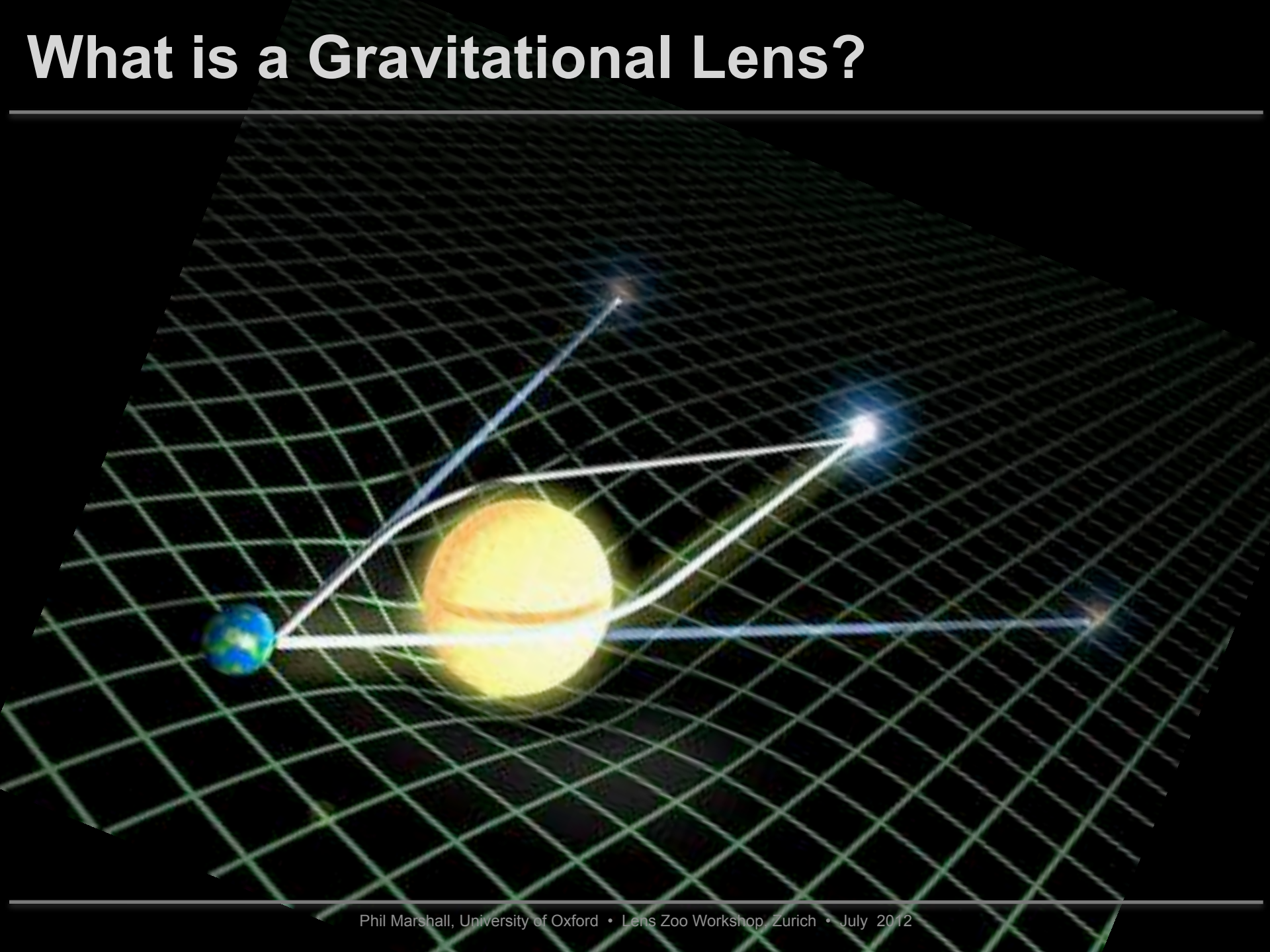
Gravitational Lenses: What types are we looking for, and where are we going to find them?

What is a Gravitational Lens?



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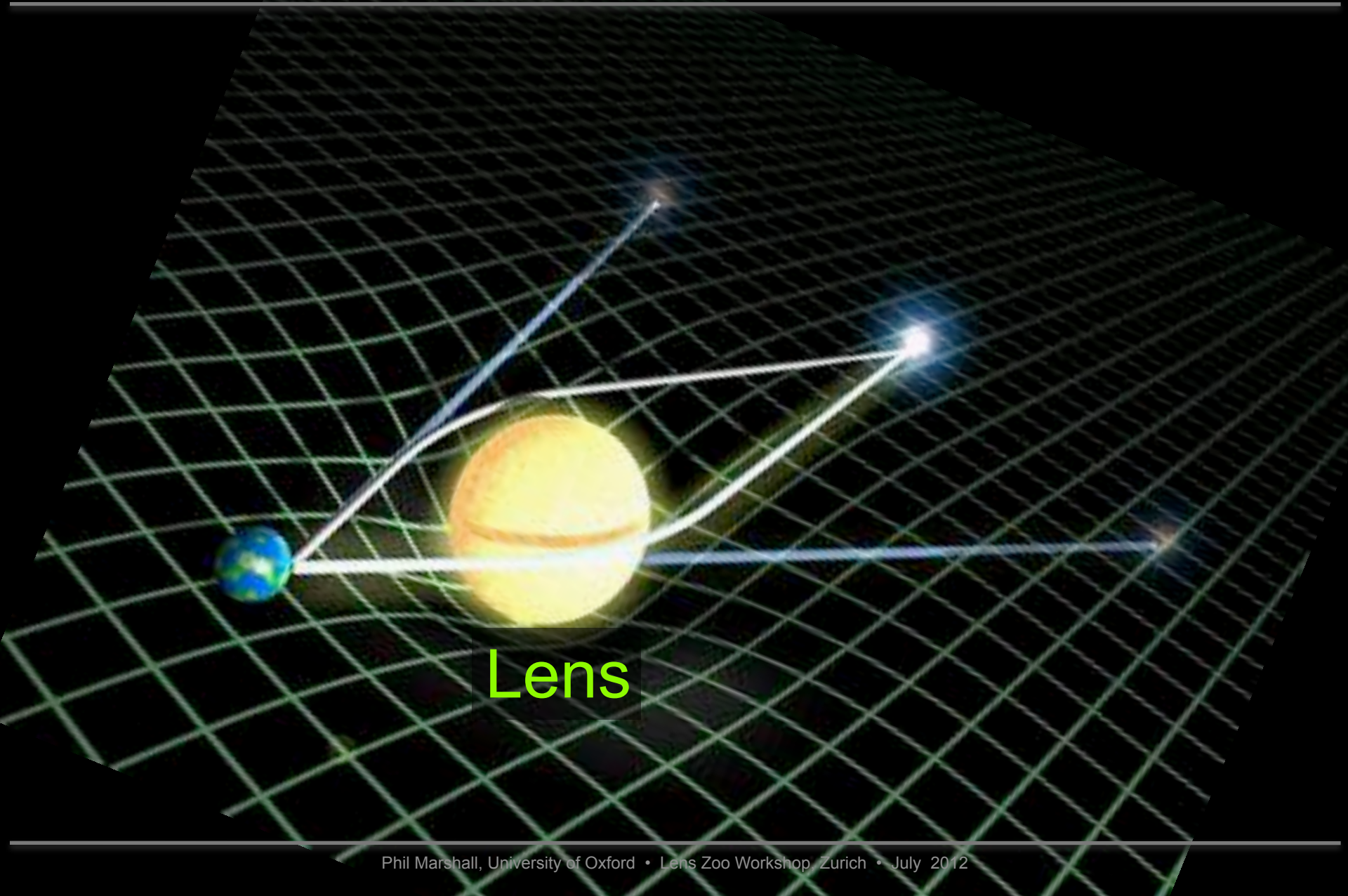

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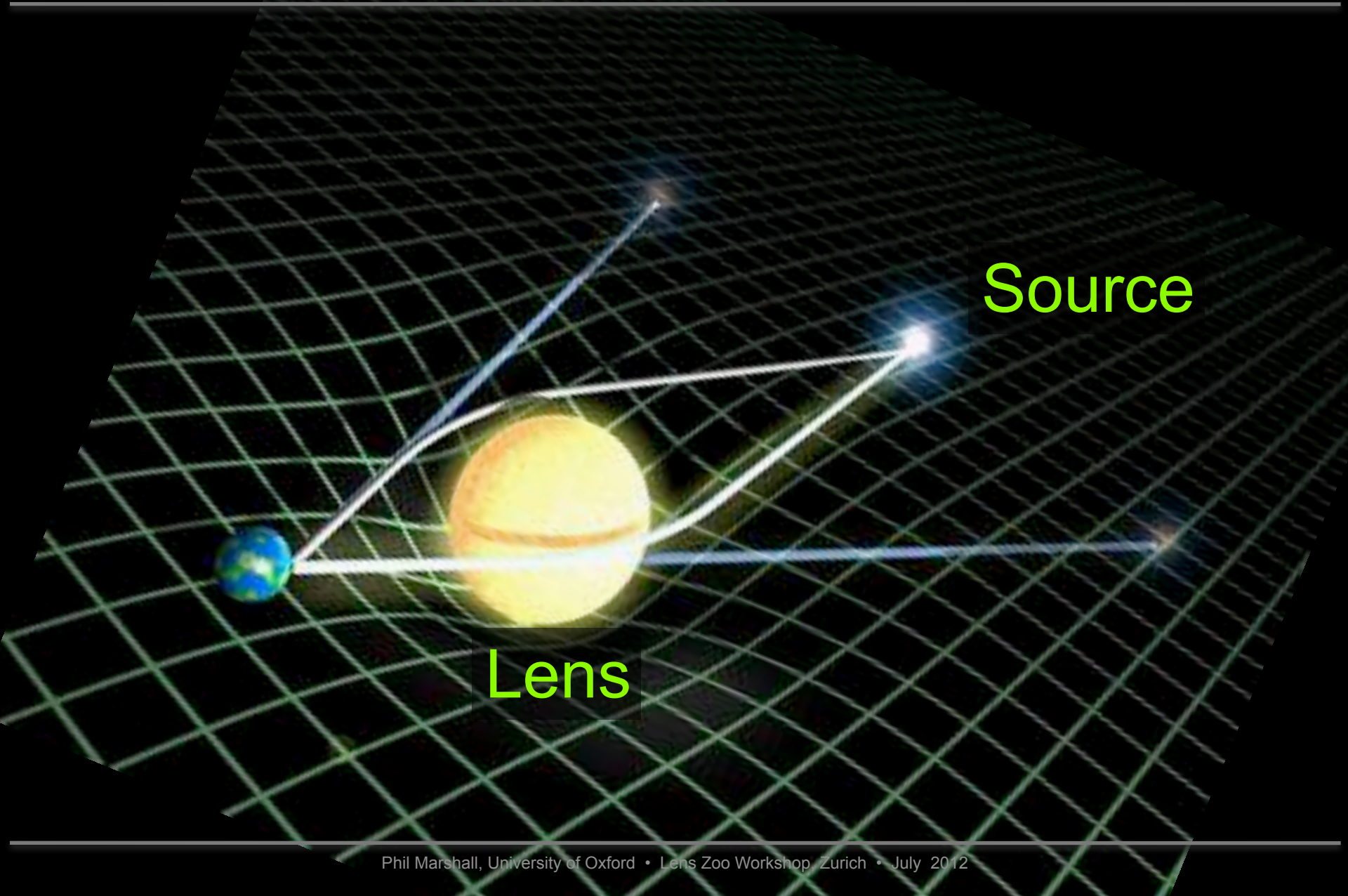

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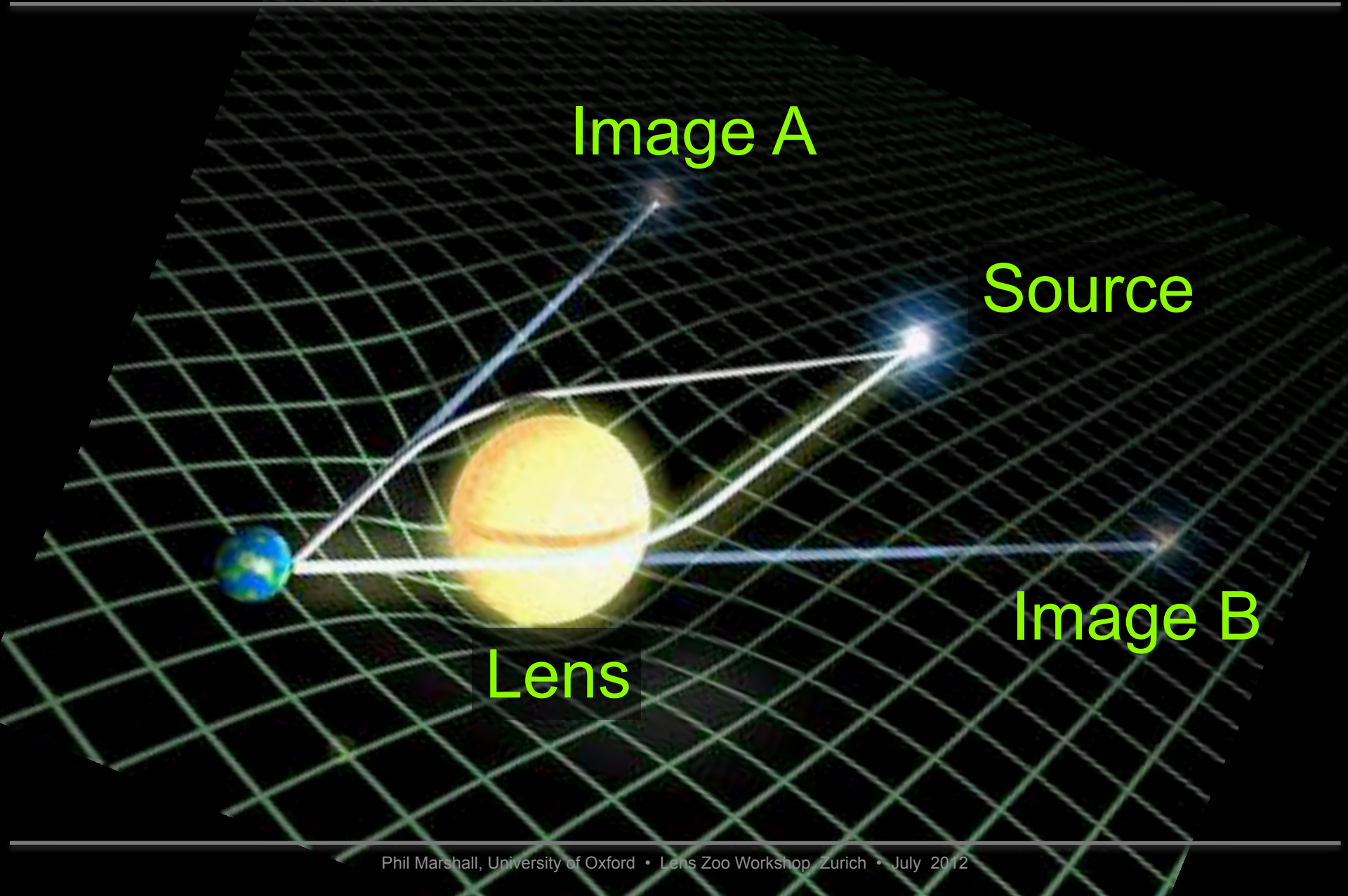
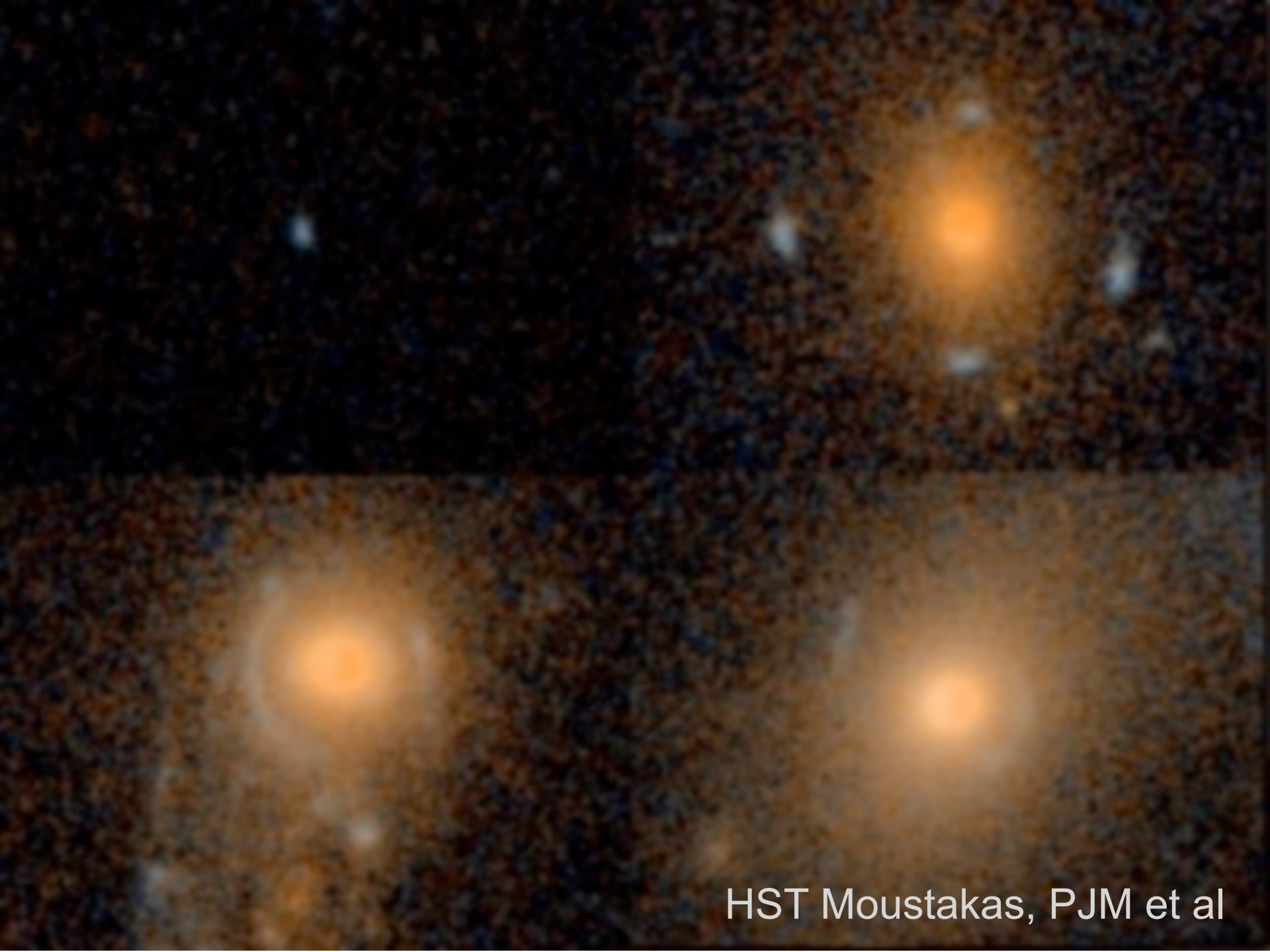
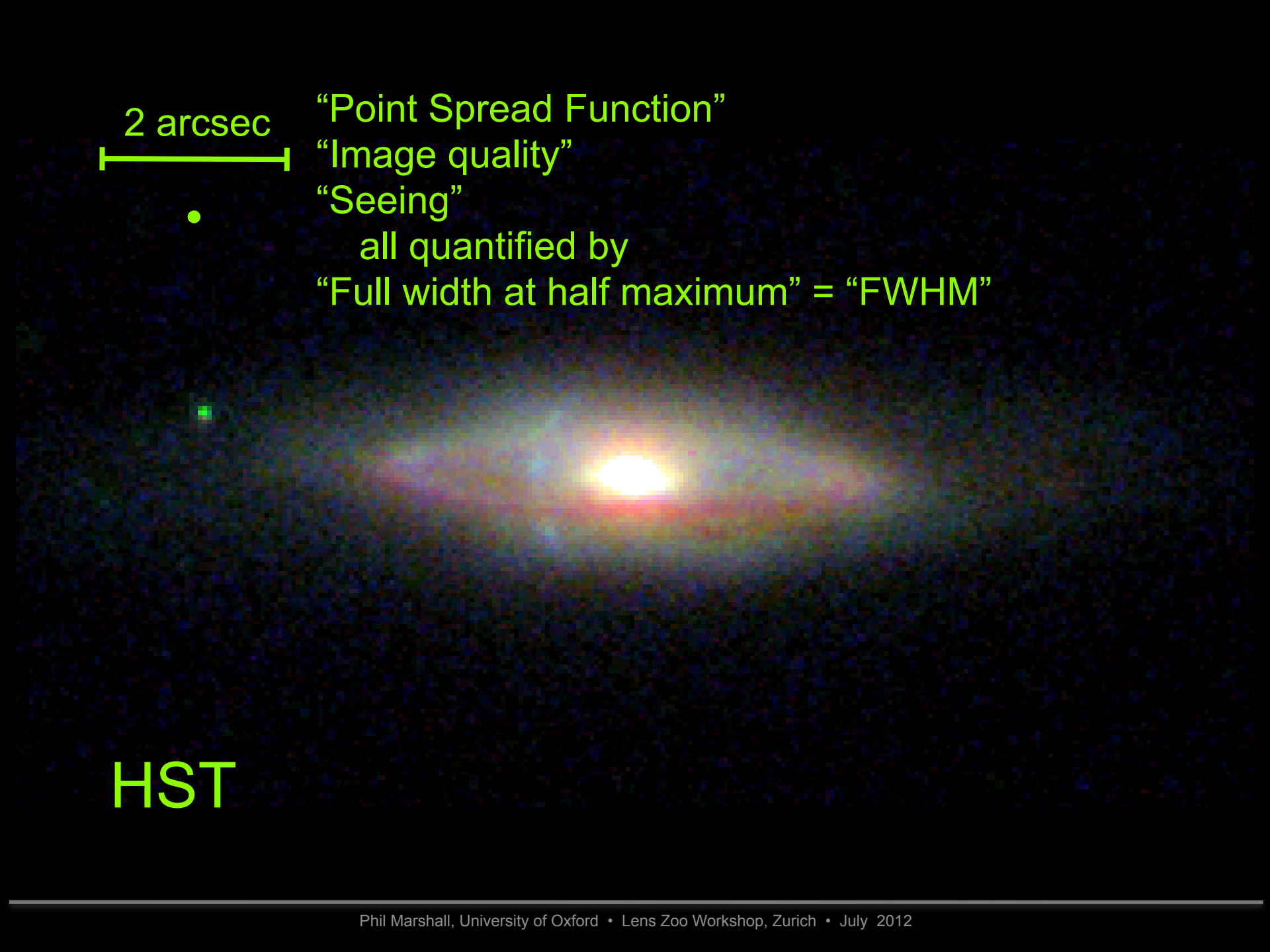



HST Moustakas, PJM et al


2 arcsec
"Point Spread Function"
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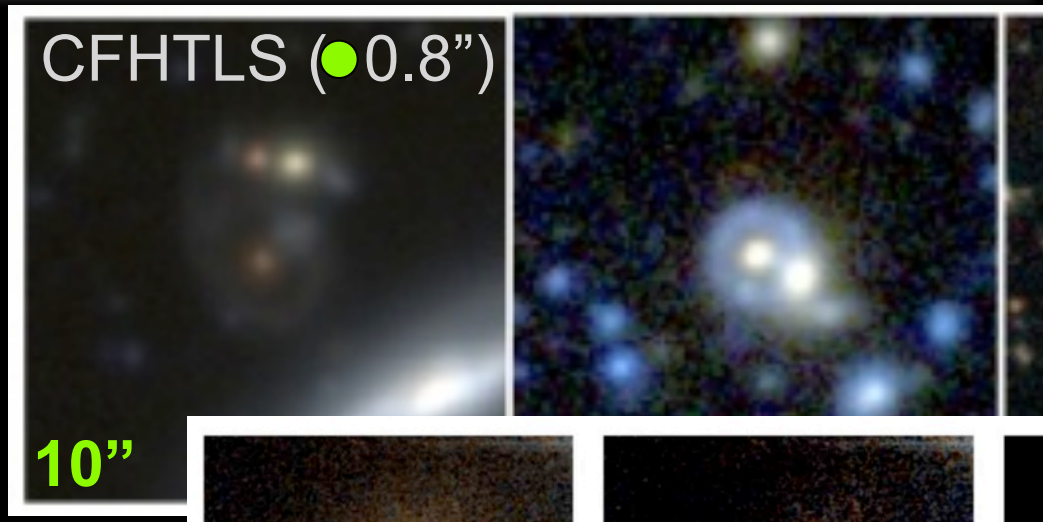
E

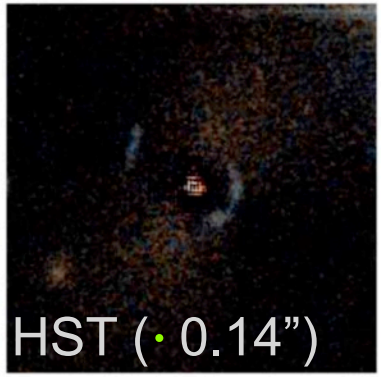
W

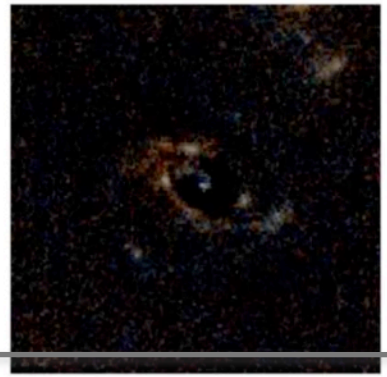
SDSS

Galaxy-scale lenses, $\Delta\theta < 3$”

- Source is most commonly a faint blue galaxy
- Confusion with spiral arms in the lens plane...







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- Details of lensing effect depend on small scale DM structure - dark sub-clumps

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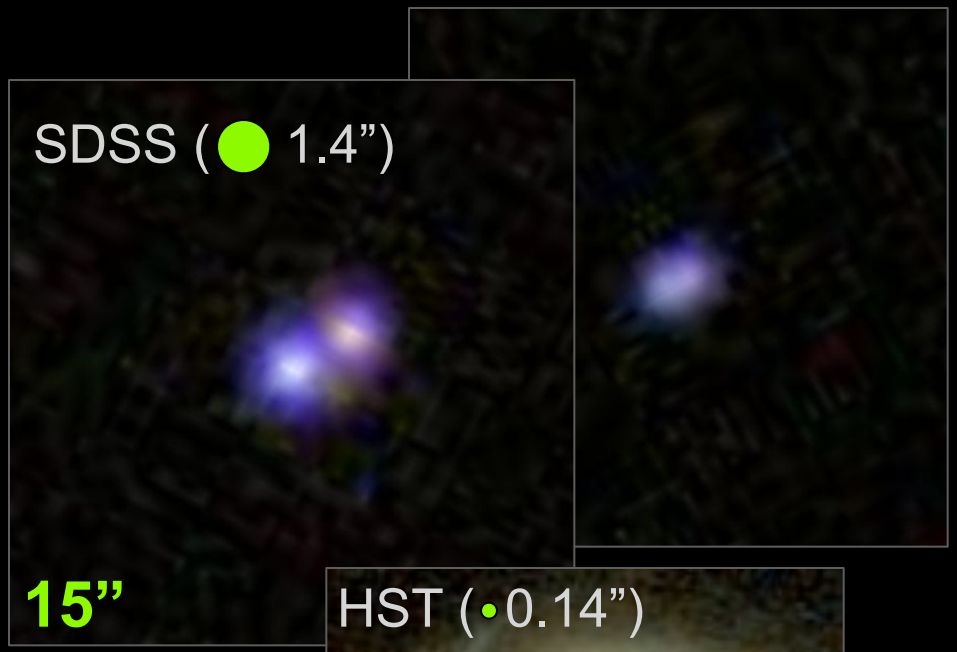
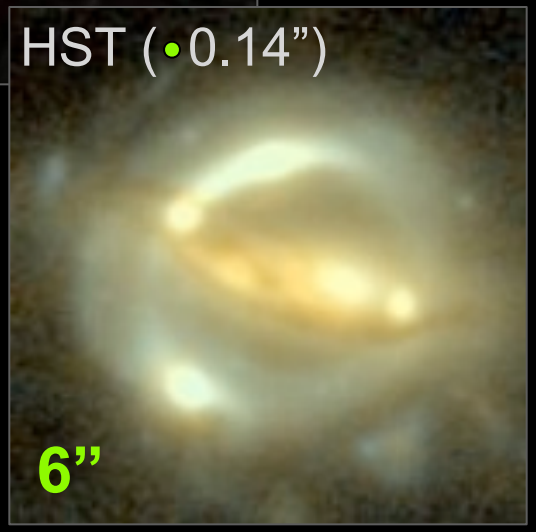
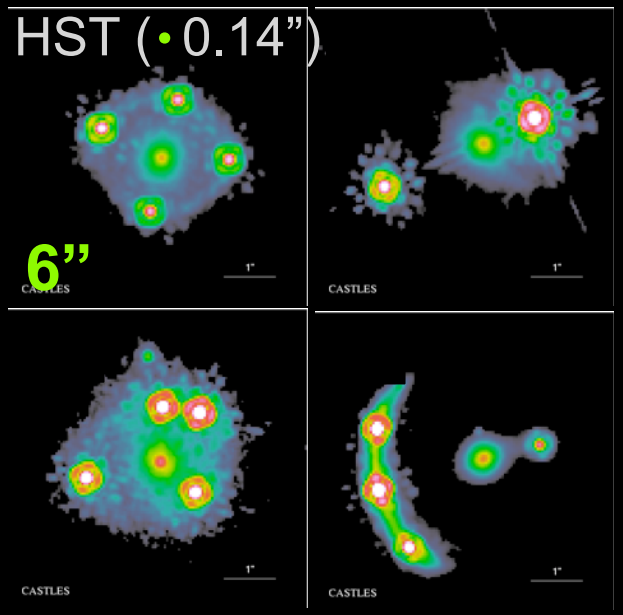




- Less common: source is a quasar
- Confusion with blue stars in the foreground...



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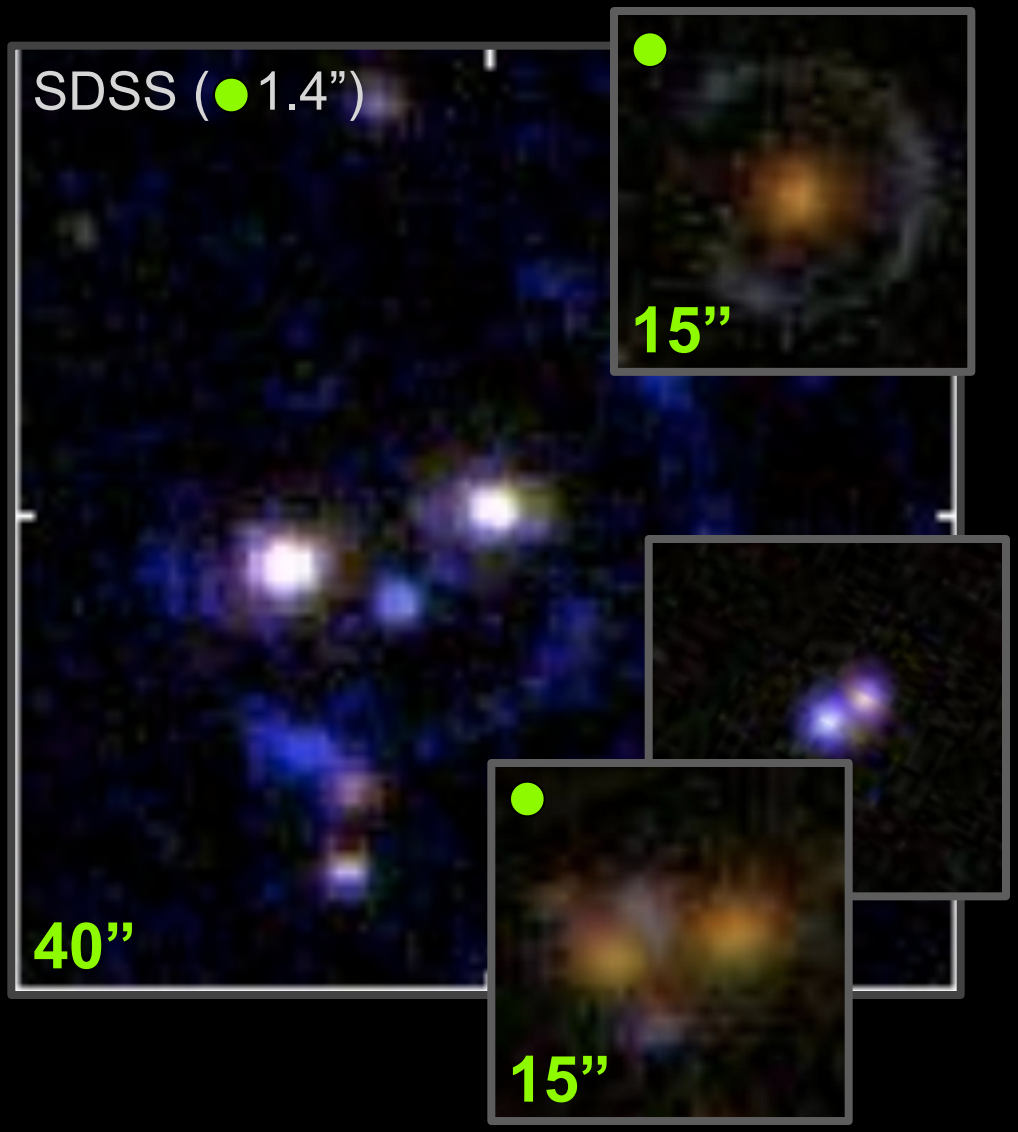
- Time delays between images: measure distance
- Anomalous flux ratios: lensing by stars ("microlensing") and DM clumps ("millilensing") in the lens galaxy

Group/cluster-scale lenses, $\Delta\theta > 3$”



- Complex systems; images better separated from lenses
- Dominate SDSS zoo

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- Images often form away from lensing galaxies, against a **dark background**
- Source galaxy is typically **small** compared to overall lens: the whole source can be highly magnified. Cosmic telescopes

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  - CFHTLS (100 sq deg): ~1 per sq deg, ~100 total

New Sky Surveys

CFHTLS: 150 sq deg, 2x resolution of SDSS and 2.5 mags deeper, robotically searched for Arcs and Rings

Can we do better than the robots? And so help improve them for the future?

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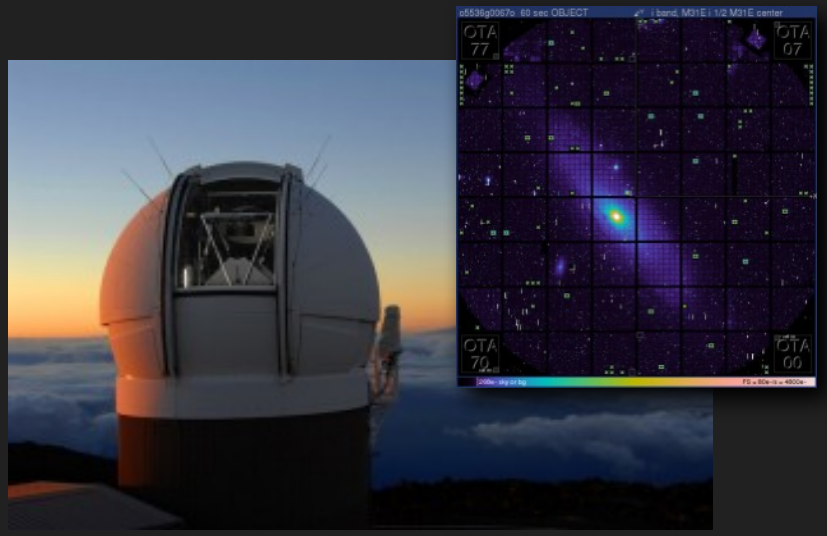

PS1 (2013+): SDSS depth but 3x area, 50% better resolution (0.7-1.3")

Thousands of galaxy groups and clusters, hundreds of lensed quasars

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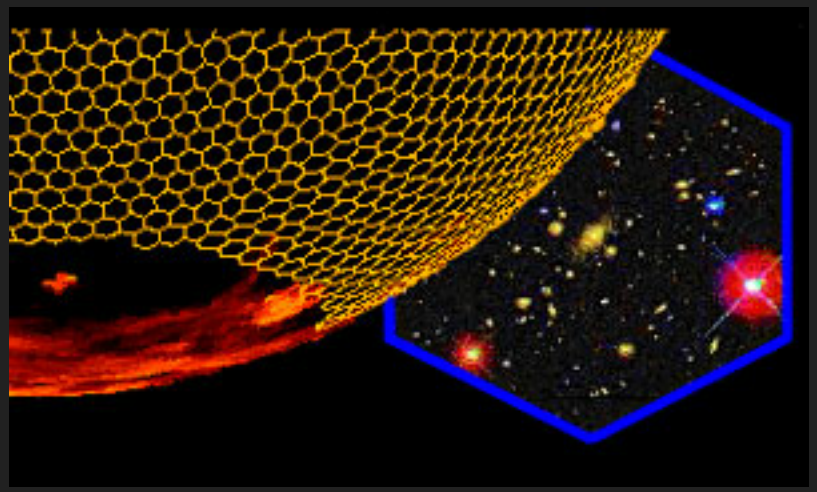
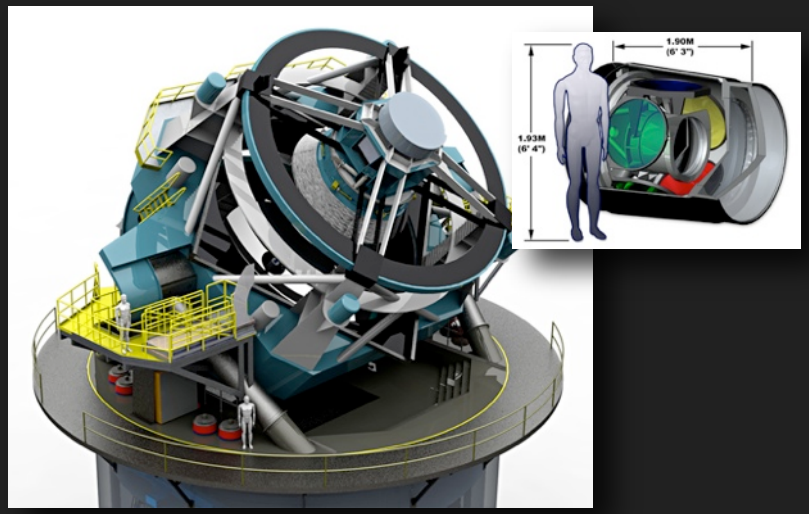


DES (2013+): 5000 sq deg, 30 times bigger than CFHTLS at similar same image quality (0.9”?)

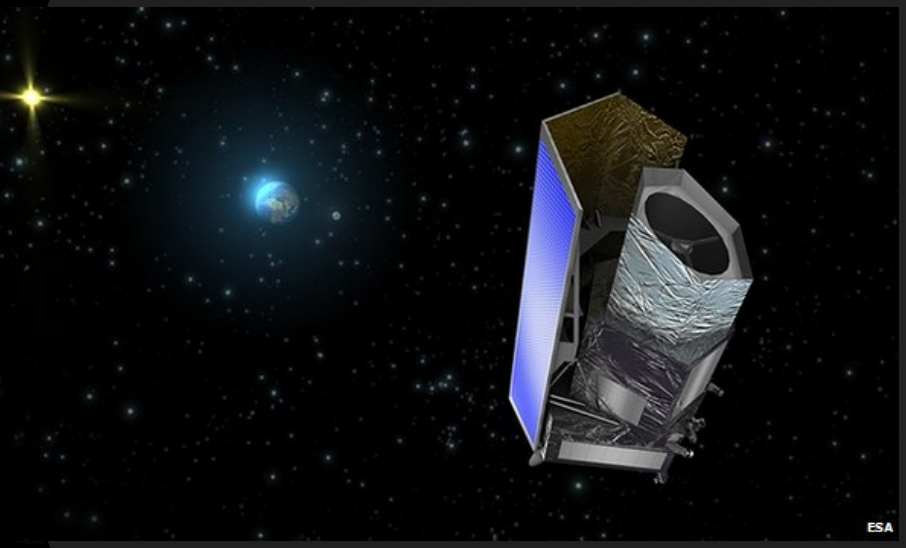
Thousands of galaxy-scale lenses, hundreds of groups

The Future (2020)



LSST: 20,000 sq deg, 0.7” seeing, 10 year survey

Tens of thousands of galaxy-scale lenses, thousands of groups and clusters, all monitored for variability



Euclid: survey space telescope, HST snapshot depth optical + NIR imaging over entire extragalactic sky

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- Provide a **high quality discovery service,** identifying and classifying good lens candidates in new and future surveys
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- Support the development of **automated lens candidate generators**, trained on zoo-classified lenses and non-lenses, to keep human inspection samples compact

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  - keep lens-hunting fun!
- Come up with some experiments for the autumn!