Galaxies Near and Far

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The University of Chicago

Our Home, The Milky Way

External Galaxies – "Island Universes"

Nature's Telescopes – Distant Galaxies

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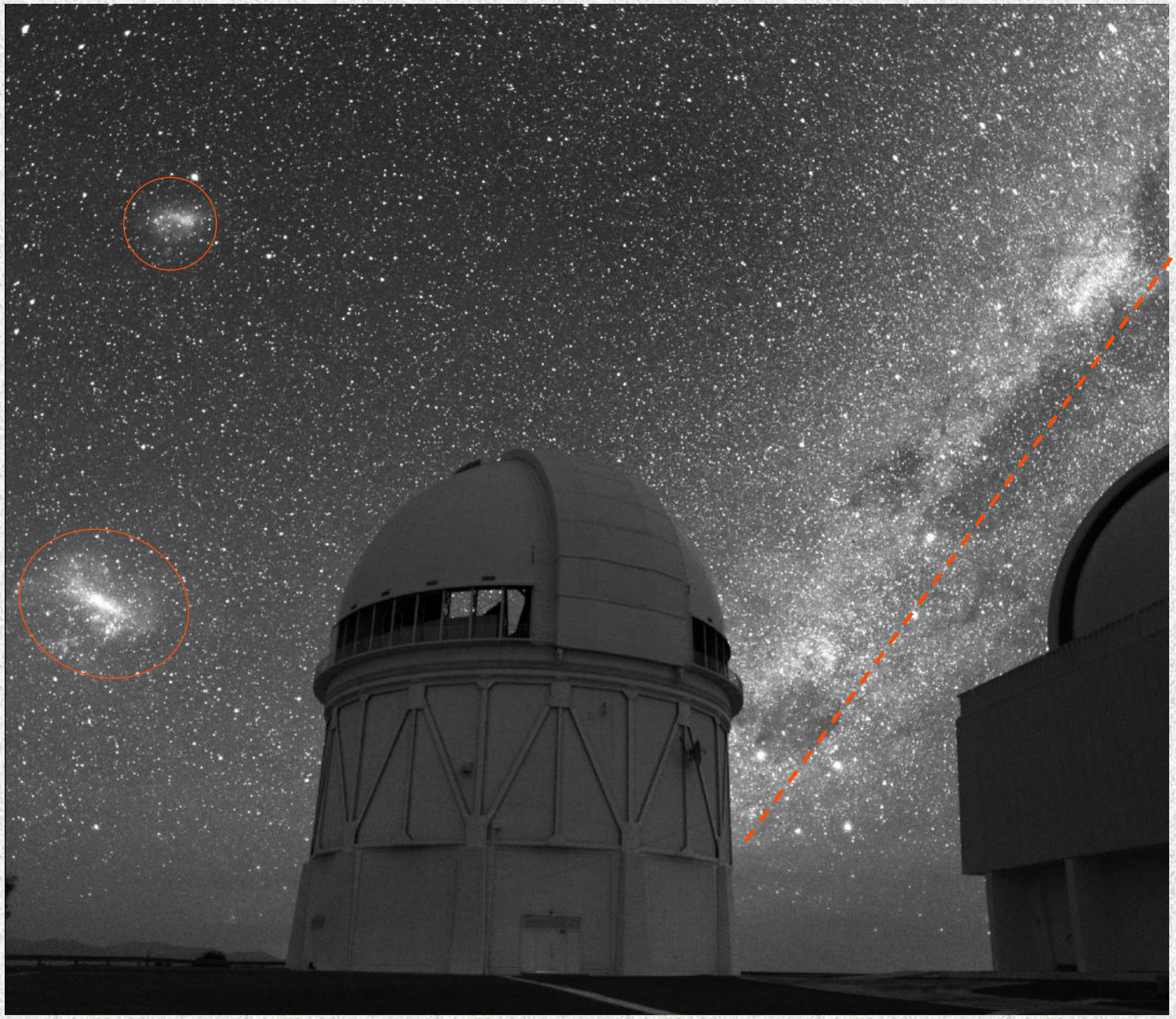
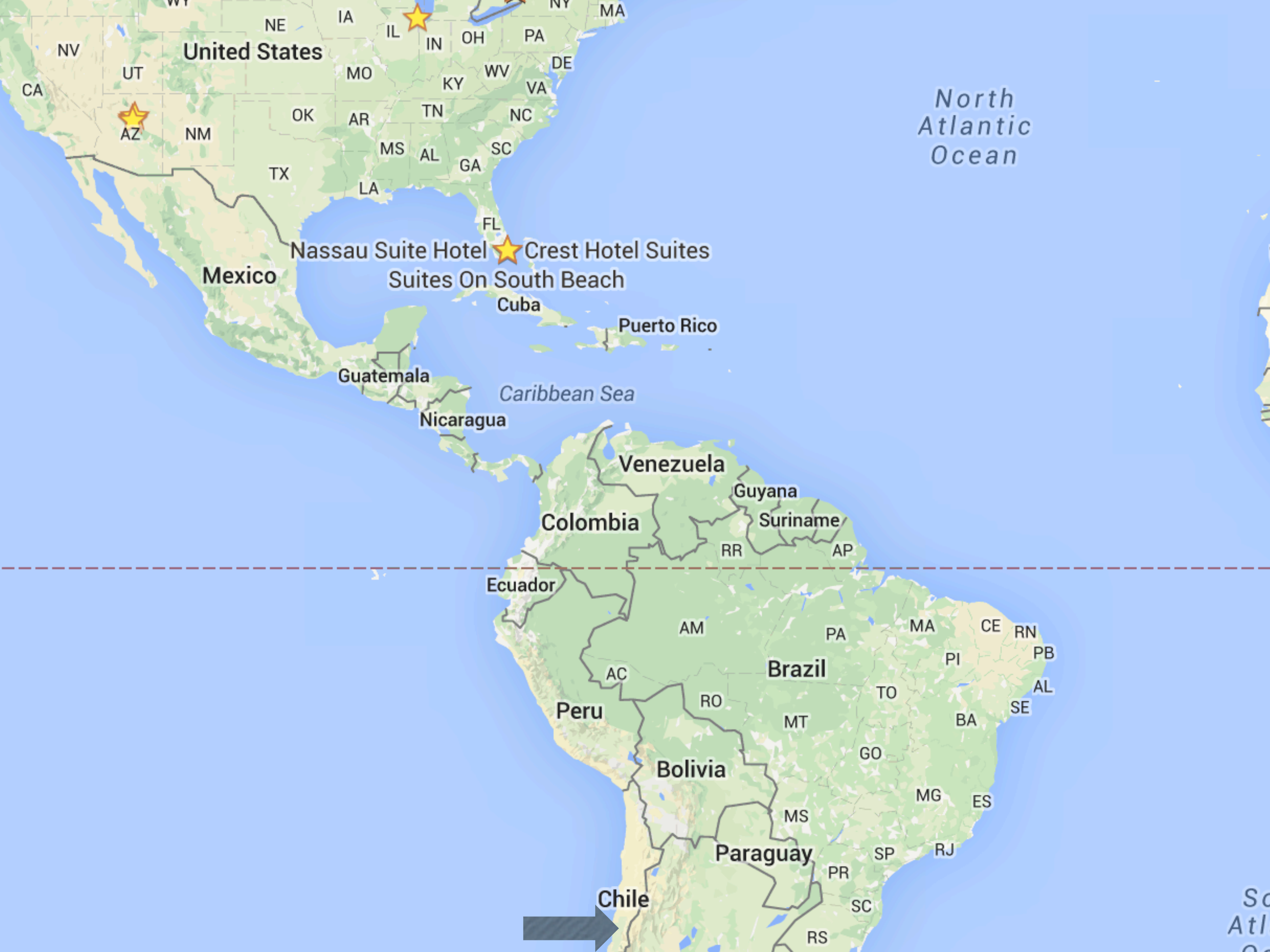
Our Galaxy: The Milky Way

To the eye, a dark night sky is not uniformly bright. A band of diffuse light mottled with dark streaks stretches across the sky

The Galaxy



The Milky Way, from the inside looking out…


United States
Mexico
Cuba
Puerto Rico
Guatemala
Caribbean Sea
Nicaragua
Venezuela
Colombia
Guyana
Suriname
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
North Atlantic Ocean
Nassau Suite Hotel
Crest Hotel Suites
Suites On South Beach
NV
UT
CA
AZ
NM
CO
NE
IA
IL
IN
OH
PA
NY
MA
DE
WV
VA
KY
MO
OK
AR
TN
NC
MS
AL
SC
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TX
LA
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RJ
PR
SC
RS
RR
AP

To find out more, it is useful to look in infrared light

2 Micron All Sky Survey

2000nm

2MASS Images

2MASS closeup of galactic center

The galactic center at even longer wavelength

Spitzer Space Telescope

4.5, 5.8 and 8 μm


At these very long wavelengths there are no longer any dark streaks
The dust which absorbs light at short wavelengths remits that energy at longer wavelengths
DIRBE/COBE
25, 60, 100 μm

Sir William Herschel (1738-1822)

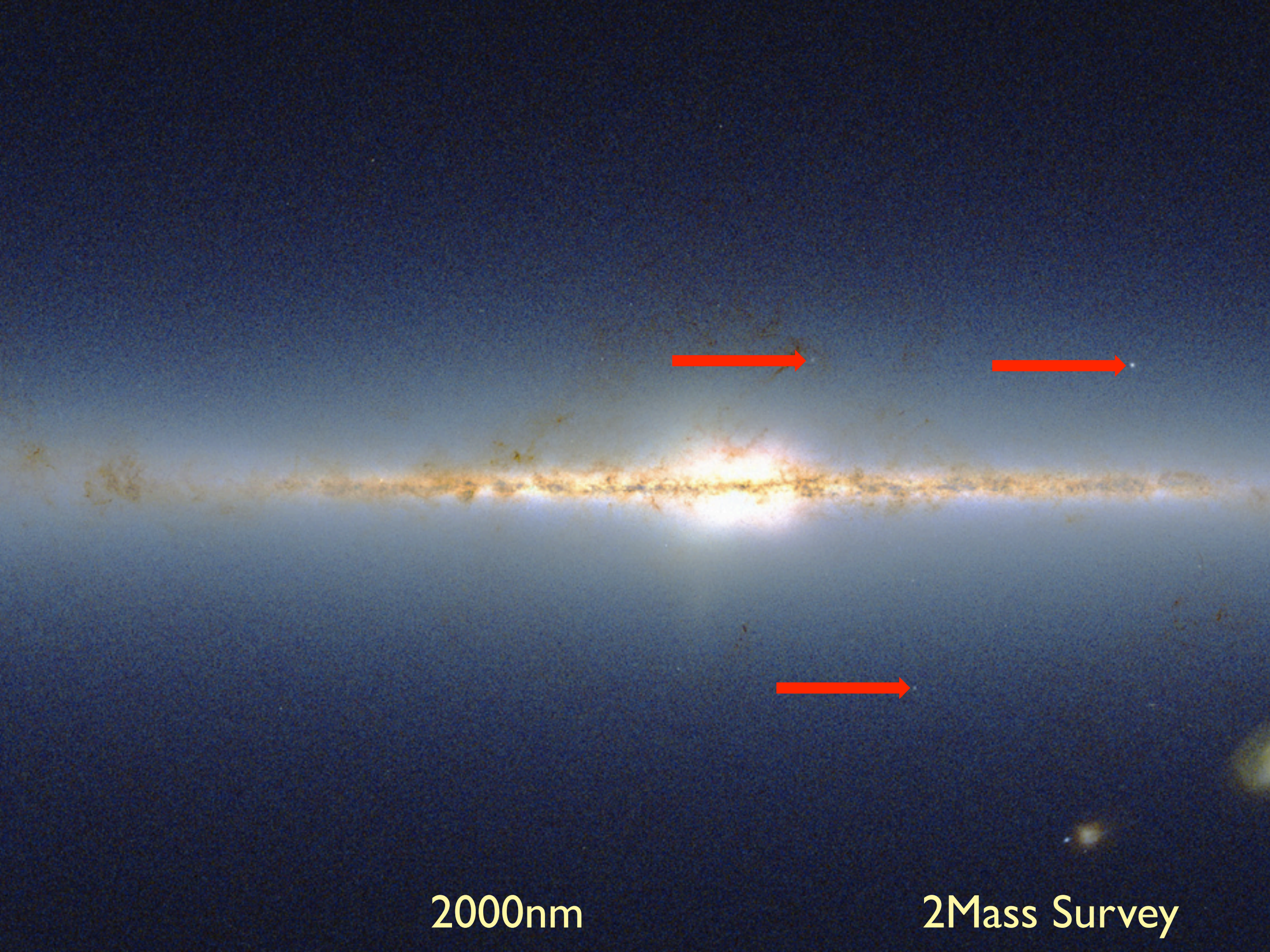
Finding our position in the Galaxy

In 1795 William Hershel tried to determine where we were in the galaxy. He counted the density of stars around the band of the Milky Way and found it to be nearly constant. He did not know about interstellar extinction due to the dust, and hence concluded that we were near the center.

As we saw from the infrared pictures, the dust, like the stars is confined to the plane of the Galaxy.

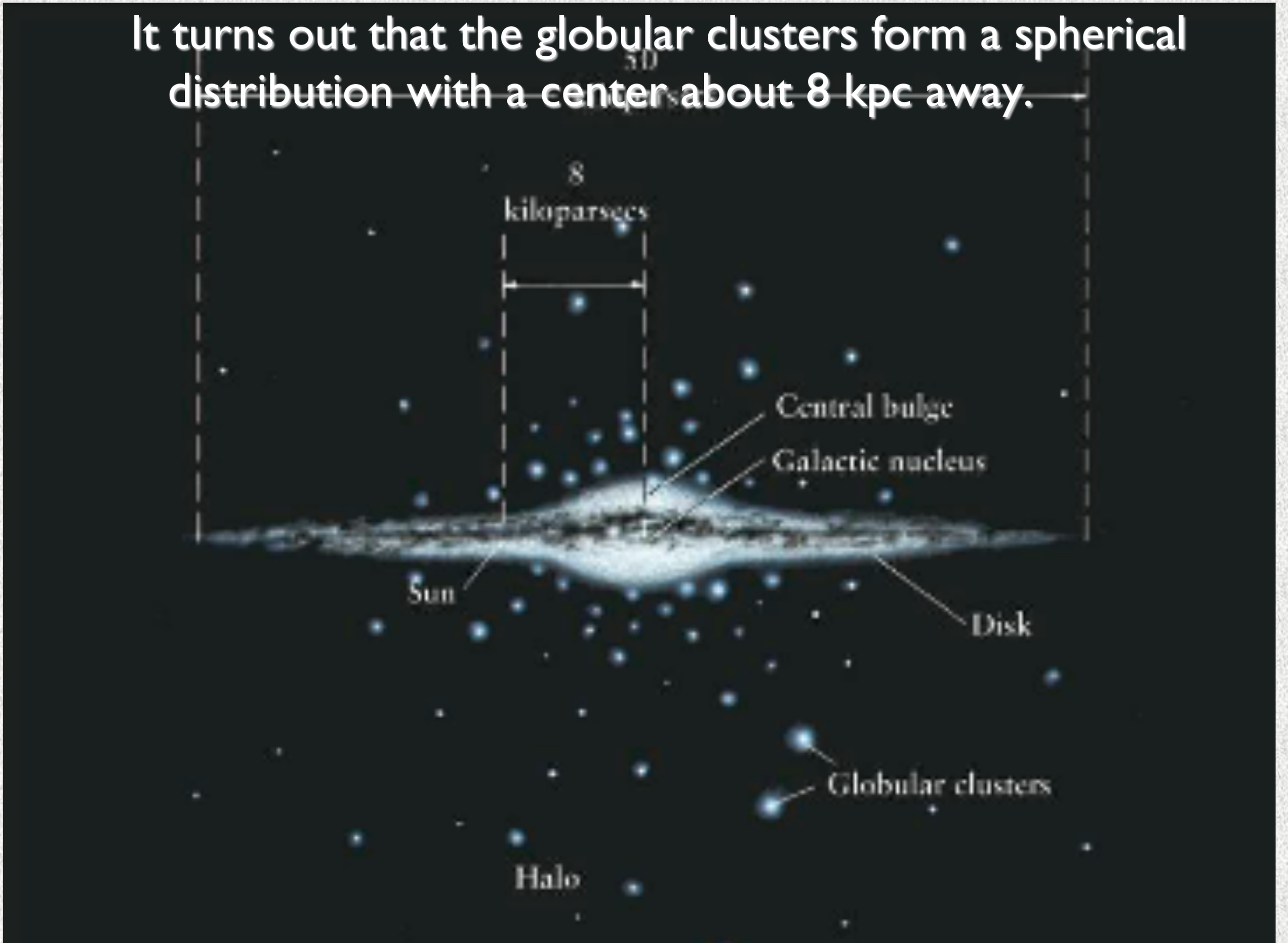
However, there are Globular Clusters, away from the plane of the galaxy that are near enough to see individual stars....

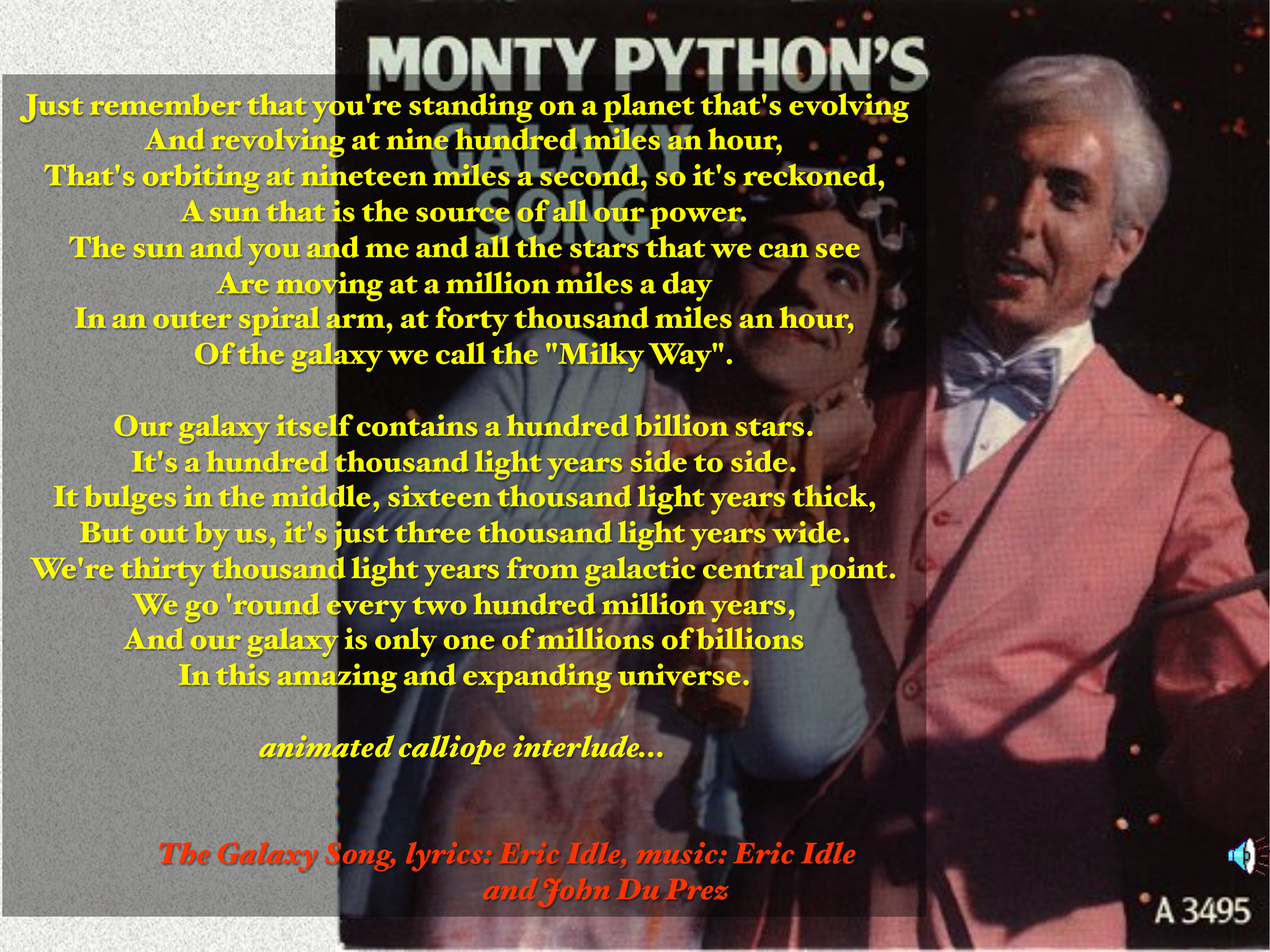
If you lived at the x, but counted stars only within the circle you would think you lived at the center...because the star counts would be relatively similar at all locations along the Milky Way


2000nm
2Mass Survey

M13

It turns out that the globular clusters form a spherical distribution with a center about 8 kpc away.





Just remember that you're standing on a planet that's evolving
And revolving at nine hundred miles an hour,
That's orbiting at nineteen miles a second, so it's reckoned,
A sun that is the source of all our power.
The sun and you and me and all the stars that we can see
Are moving at a million miles a day
In an outer spiral arm, at forty thousand miles an hour,
Of the galaxy we call the "Milky Way".

Our galaxy itself contains a hundred billion stars.
It's a hundred thousand light years side to side.
It bulges in the middle, sixteen thousand light years thick,
But out by us, it's just three thousand light years wide.
We're thirty thousand light years from galactic central point.
We go 'round every two hundred million years,
And our galaxy is only one of millions of billions
In this amazing and expanding universe.

animated calliope interlude...

The Galaxy Song, lyrics: Eric Idle, music: Eric Idle and John Du Prez

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The Andromeda Galaxy

M31

M32

M110

Hubble: 1925

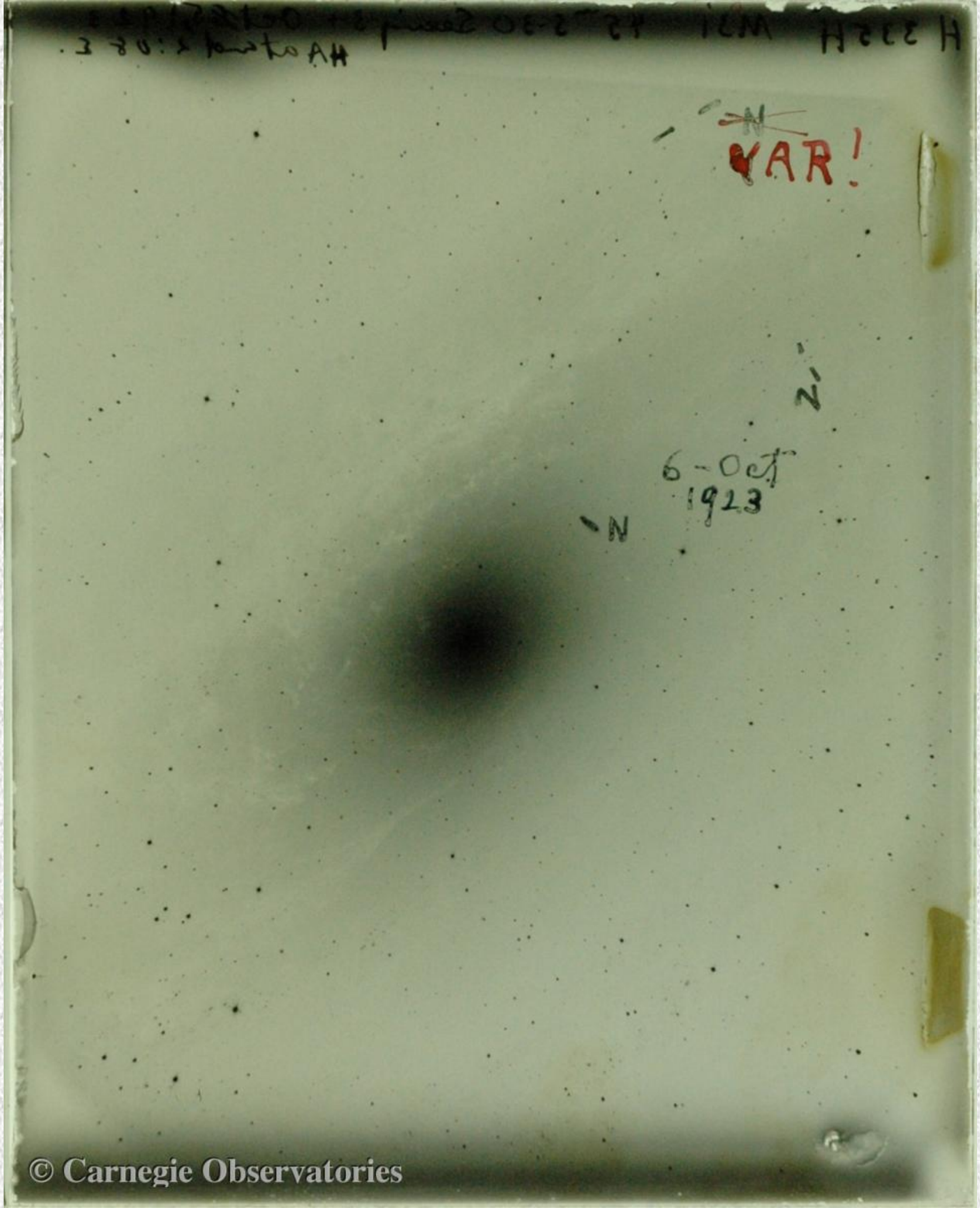
Cepheids in Spiral Nebulæ *.

Messier 31 † and 33, the only spirals that can be seen with the naked eye, have recently been made the subject of detailed investigations with the 100-inch and 60-inch reflectors of the Mount Wilson Observatory. Novæ are a common phenomenon in M 31, and Duncan has reported three variables within the area covered by M 33 ‡. With these exceptions there seems to have been no

Table II.

Cepheids in M 31. §

Var. No.	Period in Days.	Log. P.	Photographic Magnitude. Max.
5	50·17	1·70	18·4
7	45·04	1·65	18·15
16	41·14	1·61	18·6
9	38	1·58	18·3
1	31·41	1·50	18·2
12	22·03	1·34	19·0
13	22	1·34	19·0
10	21·5	1·33	18·75
2	20·10	1·30	18·5
17	18·77	1·28	18·55
18	18·54	1·27	18·9
14	18	1·26	19·1



Hubble's photographic plate, on which he discovered the first variable star in the Andromeda Galaxy!

The Telescope!

The Man!


MNC
R14
CHICAGO-18
1909
JAN.15
INDIANA-12
FLT CNTLR
OFF
PULSE
HIGH
LOW
PAYLOAD

A Piece of Chicago History:

Edwin Hubble(UChicago S.B.,1910, Ph.D.,1917) was a forward on the UChicago Big-10 Championship teams in 1907/08 and 1908/09. This is the winning game ball, now on display at the Ratner Athletic Center. The photo was taken by astronaut John Grundsfeld (UChicago S.M.,'84, Ph.D.,'88), from inside the Space Shuttle, during the last servicing mission for the Hubble Space Telescope.

his study of globular clusters, is constructed on a basis of visual magnitudes. It can be reduced to photographic magnitudes by means of his relation between period and colour-index, given in the same paper, and the result represents his original data. The slope is of the order of that for spirals, but is not precisely the same. In comparing the two, greater weight must be given to the brighter portion of the curve for the spirals, because of the greater reliability of the magnitude determinations. When this is done, the resulting values of $M-m$ are $-21^{m}.8$ and $-21^{m}.0$ for M 31 and M 33 respectively. These must be corrected by half the average ranges of the Cepheids in the two spirals, and the final values are then on the order of $-22^{m}.3$ for both nebulæ. The corresponding distance is about 285,000 parsecs *. The greatest uncertainty is probably in the zero-point of Shapley's curve.

The results rest on three major assumptions: (1) The variables are actually connected with the spirals; (2) There is no serious amount of absorption due to amorphous nebulosity in the spirals; (3) The nature of Cepheid variation is uniform throughout the observable portion of the universe. As for the first, besides the weighty arguments based on analogy and probability, it may be mentioned that no Cepheids have been found on the several plates of the neighbouring selected areas Nos. 21 and 45, on a special series of plates centred on BD+35°207, just midway between the two spirals, nor in ten other fields well distributed in galactic latitude, for which six or more long exposures are available. The second assumption is very strongly supported by the small dispersion in the period-luminosity curve for M 33. In M 31, in spite of the somewhat larger dispersion, there is no evidence of an absorption-effect to be measured in magnitudes.

These two spirals are not unique. Variables have also been found in M 81, M 101, and N.G.C. 2403, although as yet sufficient plates have not been accumulated to determine the nature of their variation.

EDWIN P. HUBBLE.

Distances

Size of campus: ~1 km

x1100

Chicago to New York: ~1 100 km

x360

Earth to the Moon: ~400 000 km

x375

Size of Earth's Orbit: ~150 000 000 km (1AU)

x100

Distance to Eris: ~14 700 000 000 km

x2800

Distance to Alpha Centauri: ~39 900 000 000 000 km

x340

Distance to Orion Nebula: ~13 500 000 000 000 000 km

x18

Distance to Galactic Center ~239 400 000 000 000 000 km

x100

Distance to Andromeda: ~24 000 000 000 000 000 000 km (0.66Mpc)

NGC 4321 / UGC 7450 / VCC 596

SDSS *gri* image

2.0 arcmin

Large Magellanic Cloud

Perspective Matters!

NGC 4203

NGC 4298

Galaxy Collisions!

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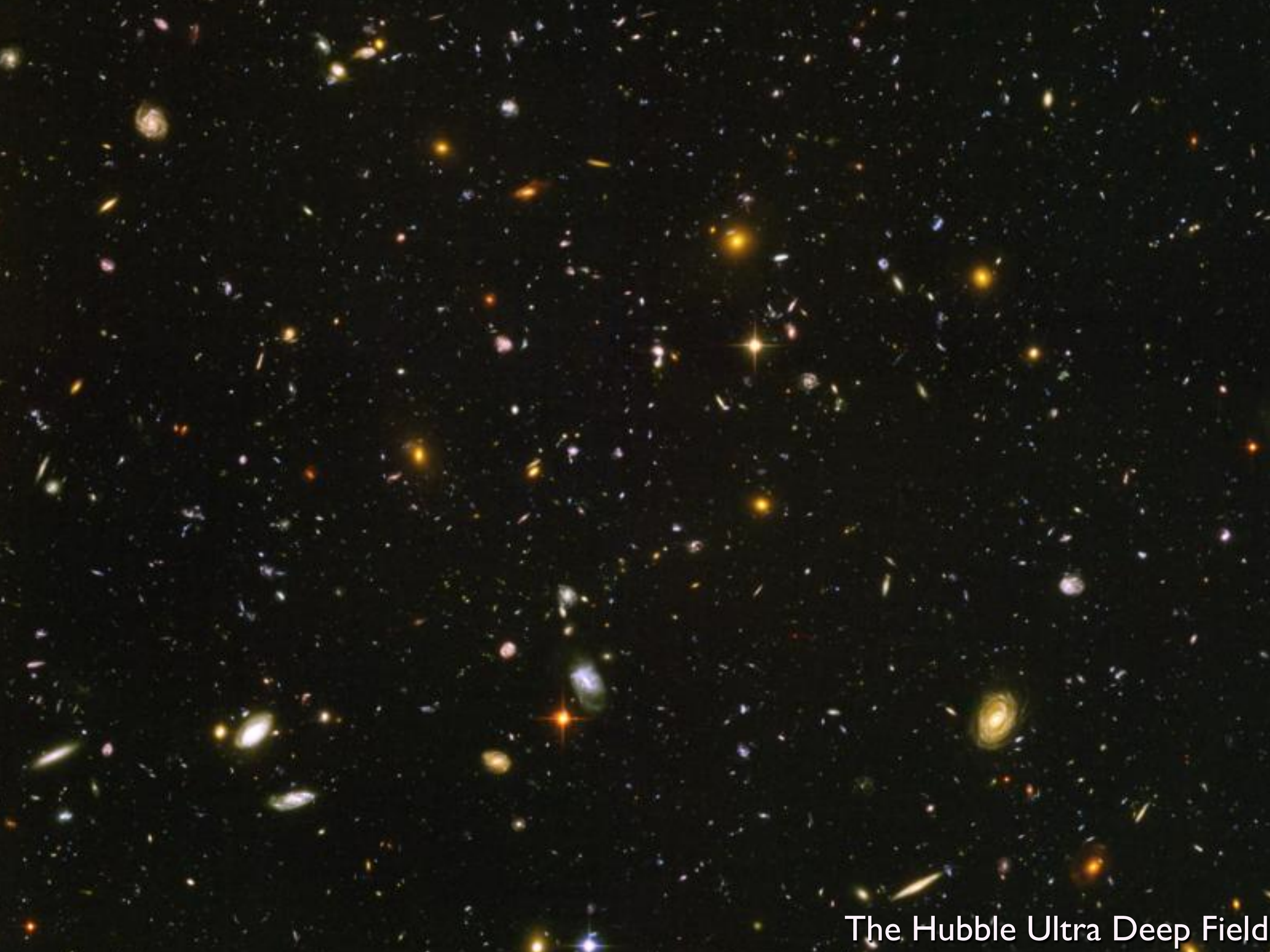
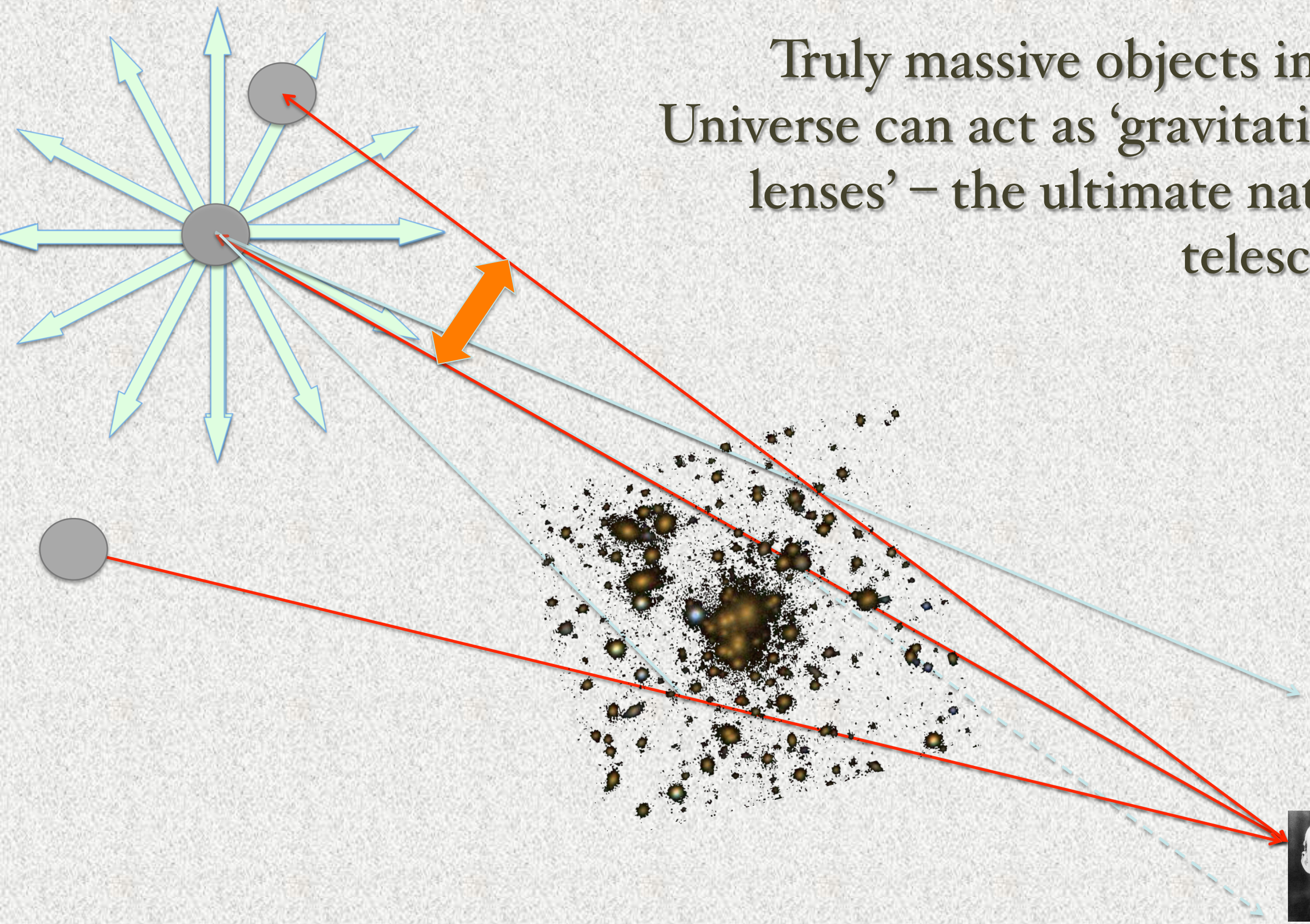


The Hubble Ultra Deep Field

Gravitational Lensing

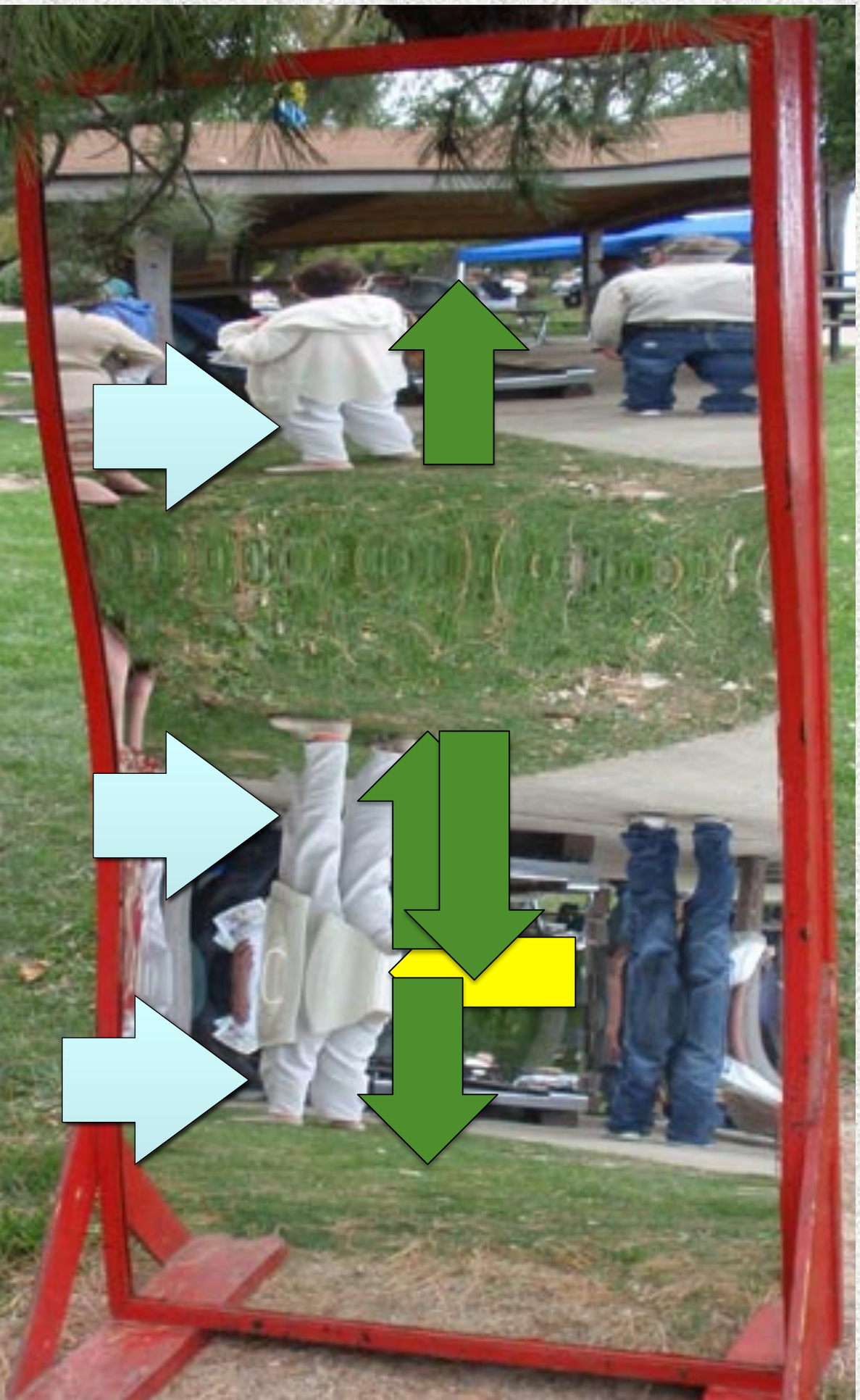
Truly massive objects in the Universe can act as 'gravitational lenses' – the ultimate natural telescope!



The World in the Funhouse Mirror

•objects in the mirror may not be as they appear! Optics distort images...

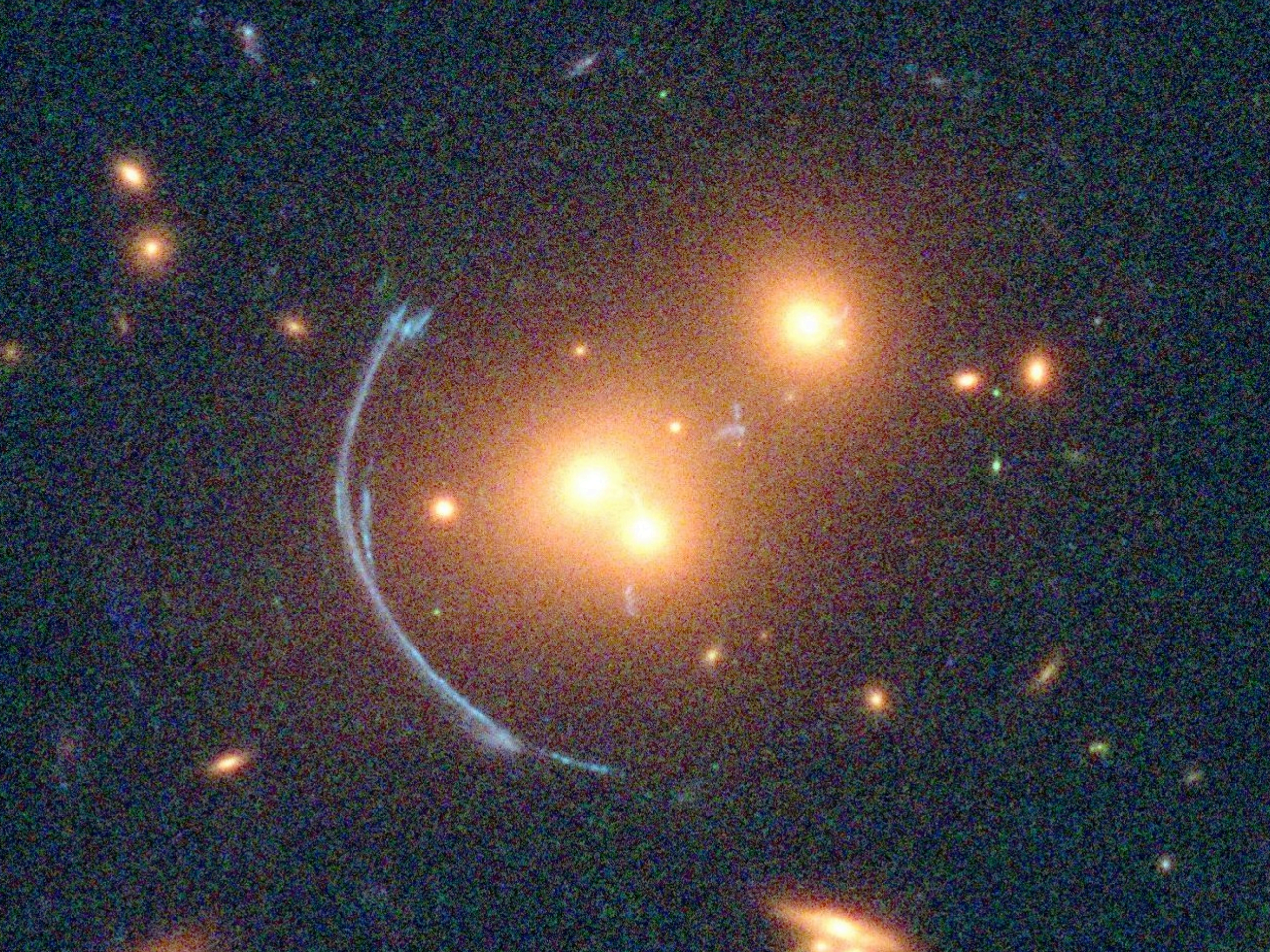
•but how would you know? If we remove the context, do you still see the distortion?

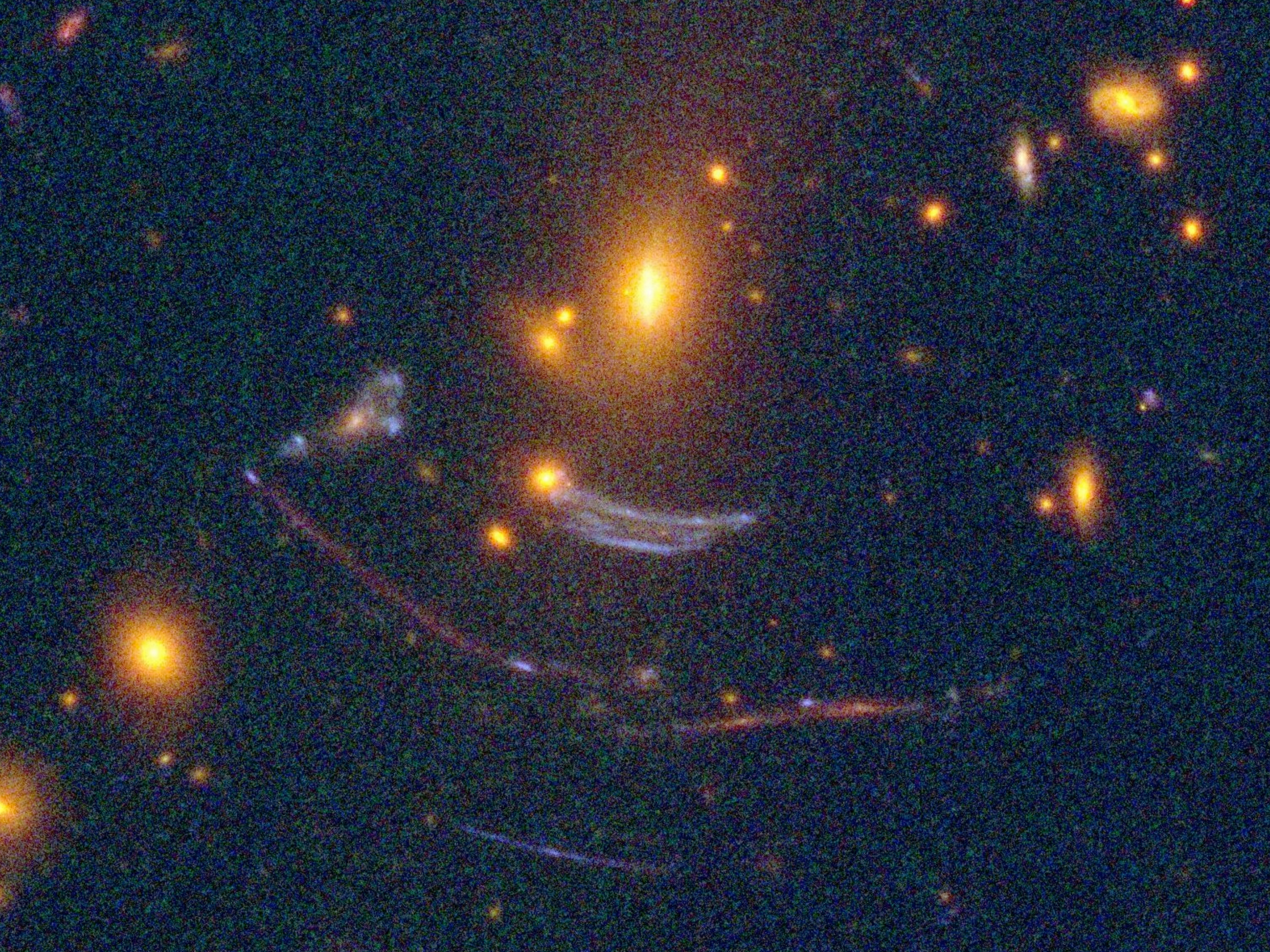


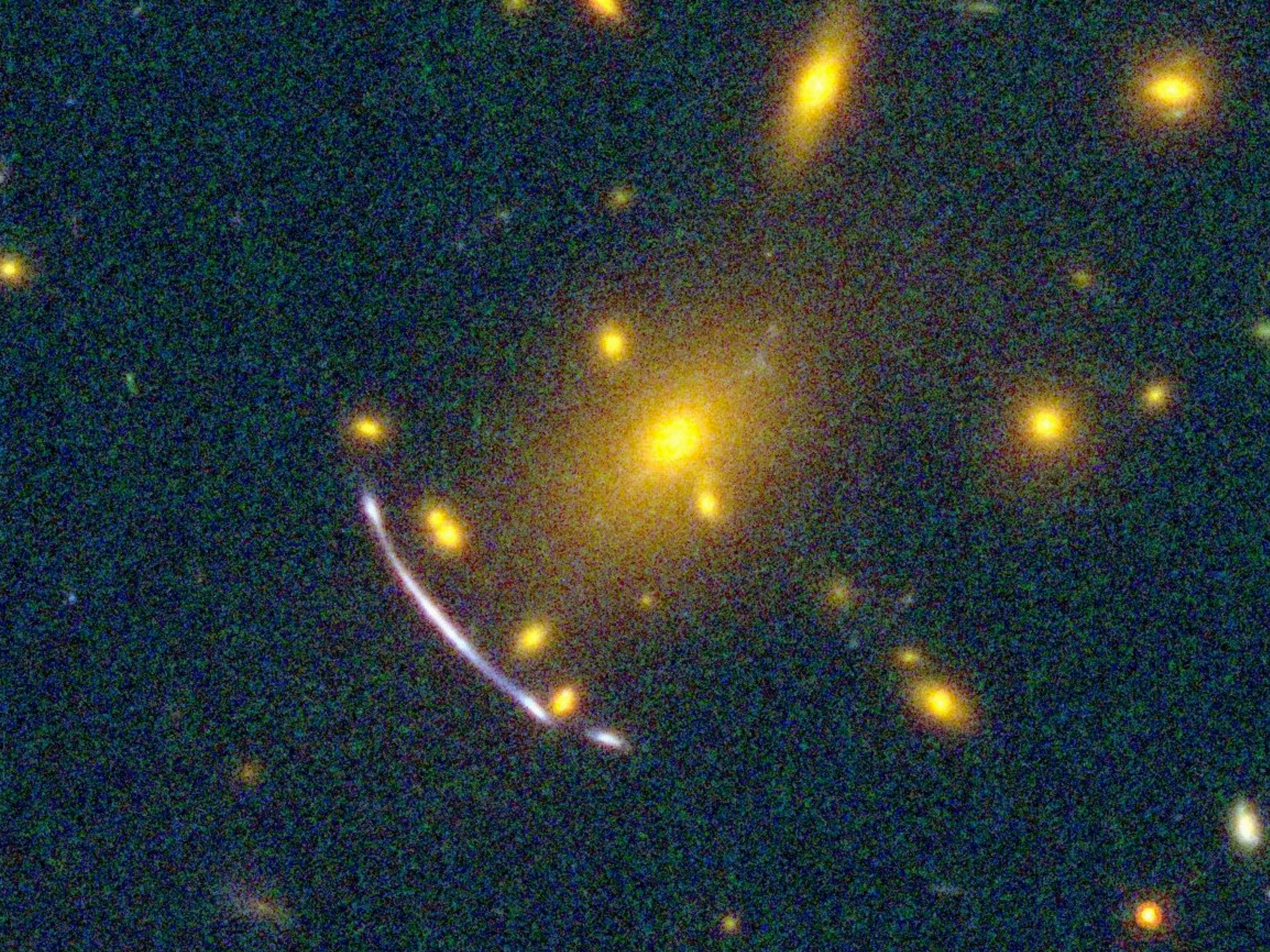
Seeing Double

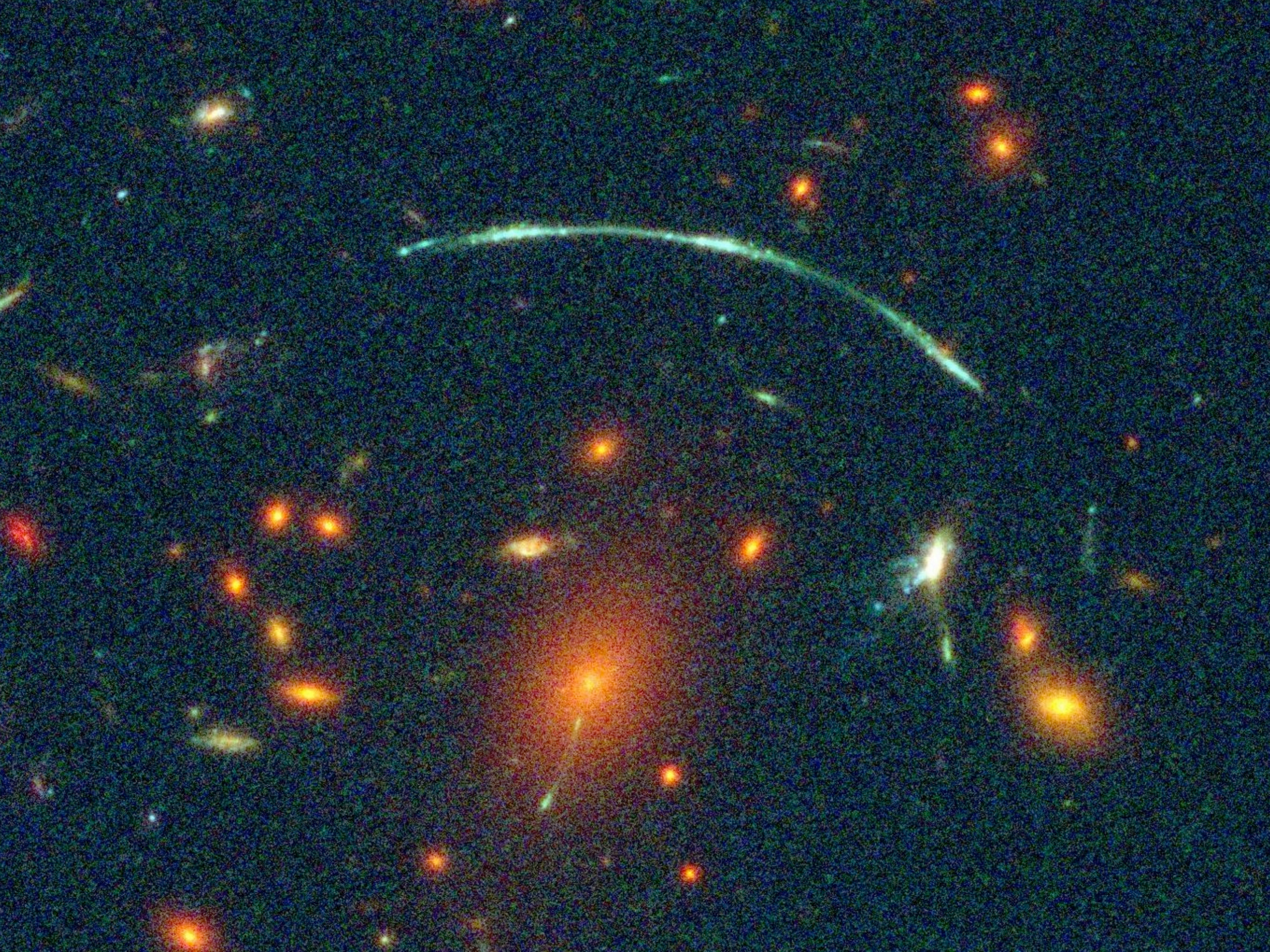
- extreme optics can produce multiple images of the same source

- the images can be distorted, or partial, and parity reversals are typical









One More Thing... Louis is Doing Well!

His Ph.D. defense is scheduled for July 13th... I received a copy of his thesis yesterday!