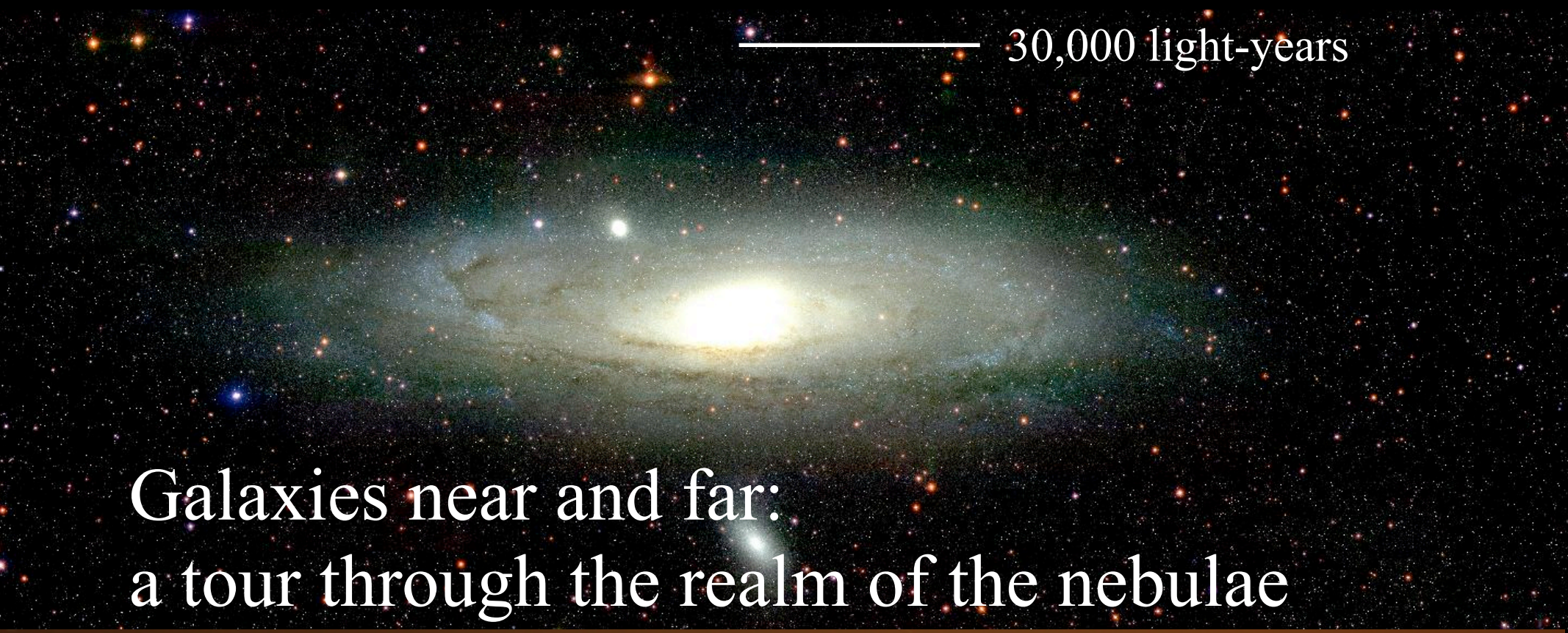


Galaxies near and far: a tour through the realm of the nebulae

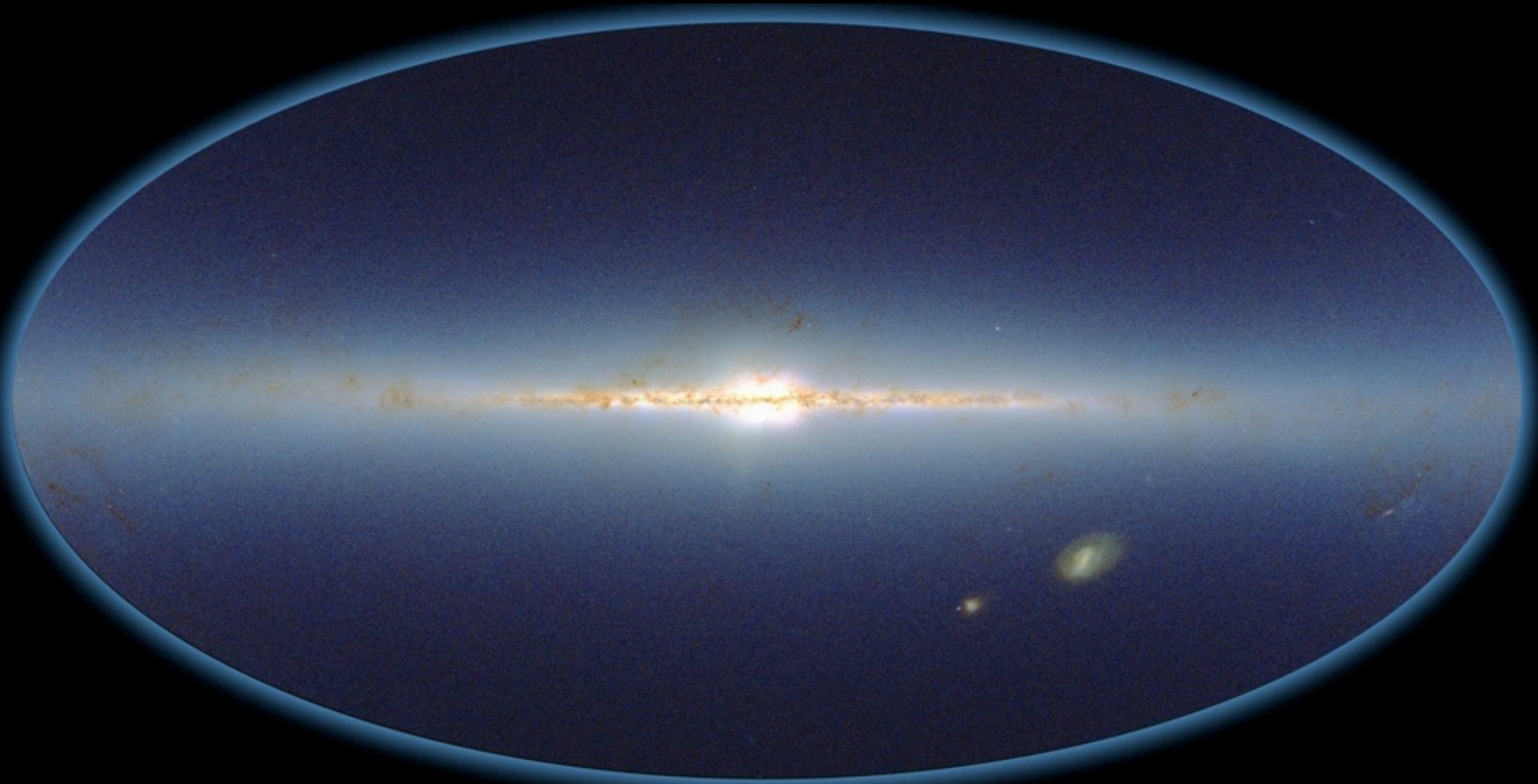
July 9, 2011
Lick Observatory Music of the Spheres

Richard G. Kron
The University of Chicago


backyard photo of our home galaxy, the Milky Way

the Milky Way in Sagittarius

all-sky view of the Milky Way and the Small and Large Magellanic Clouds



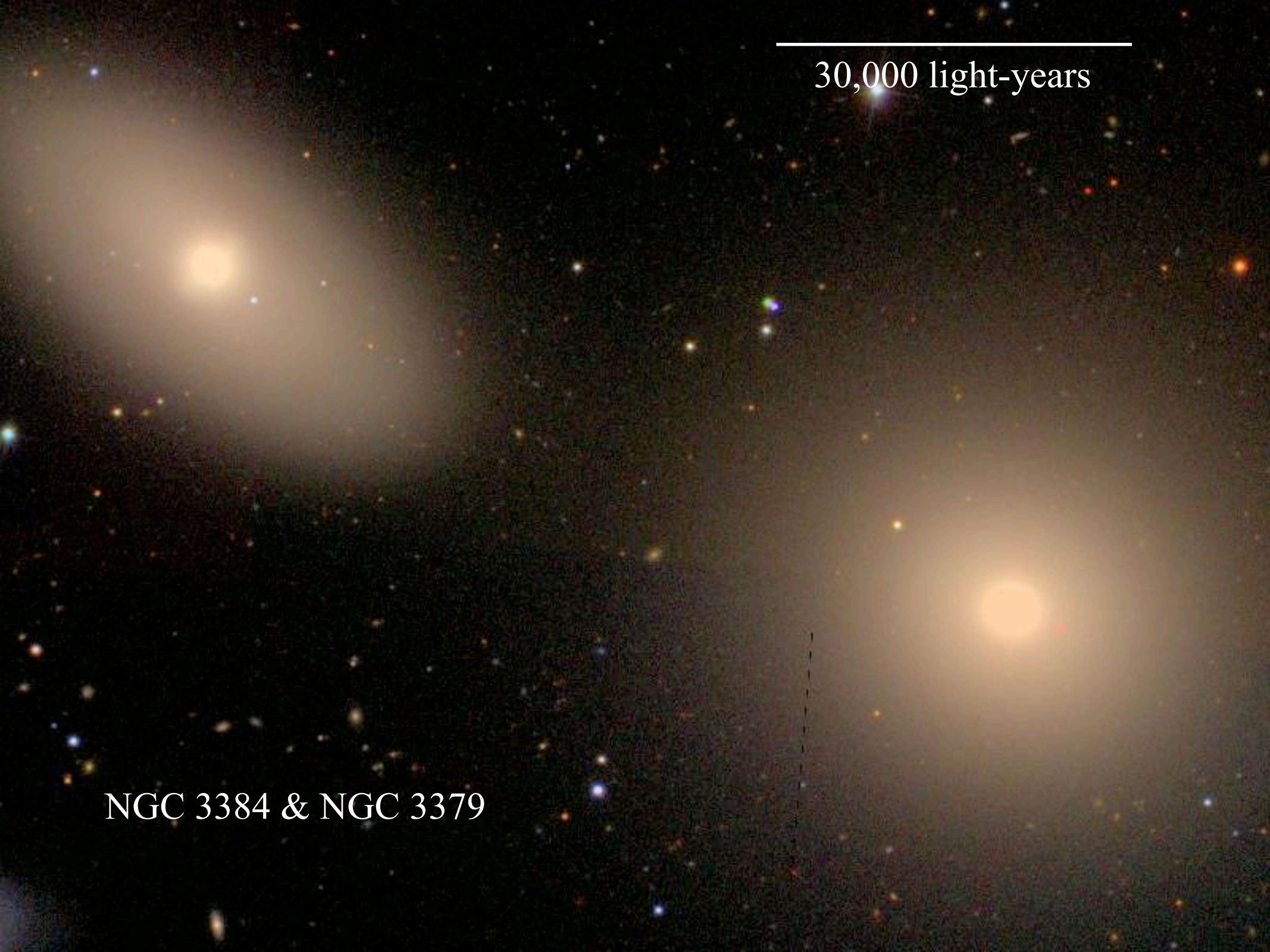
H.D. Curtis suggested that spiral nebulae were like the Milky Way (“island universes”)

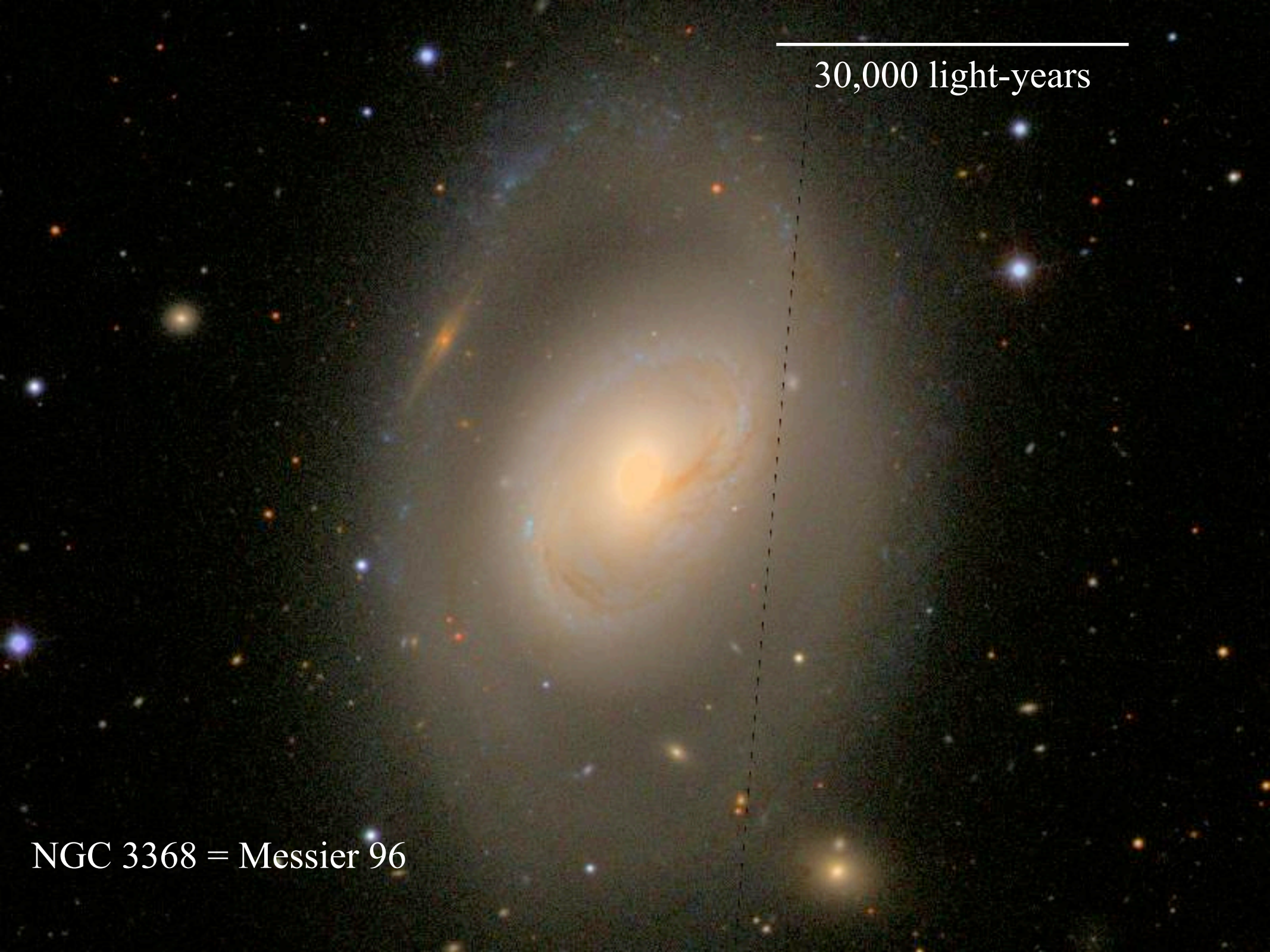

The Milky Way is about 100 thousand light-years across.

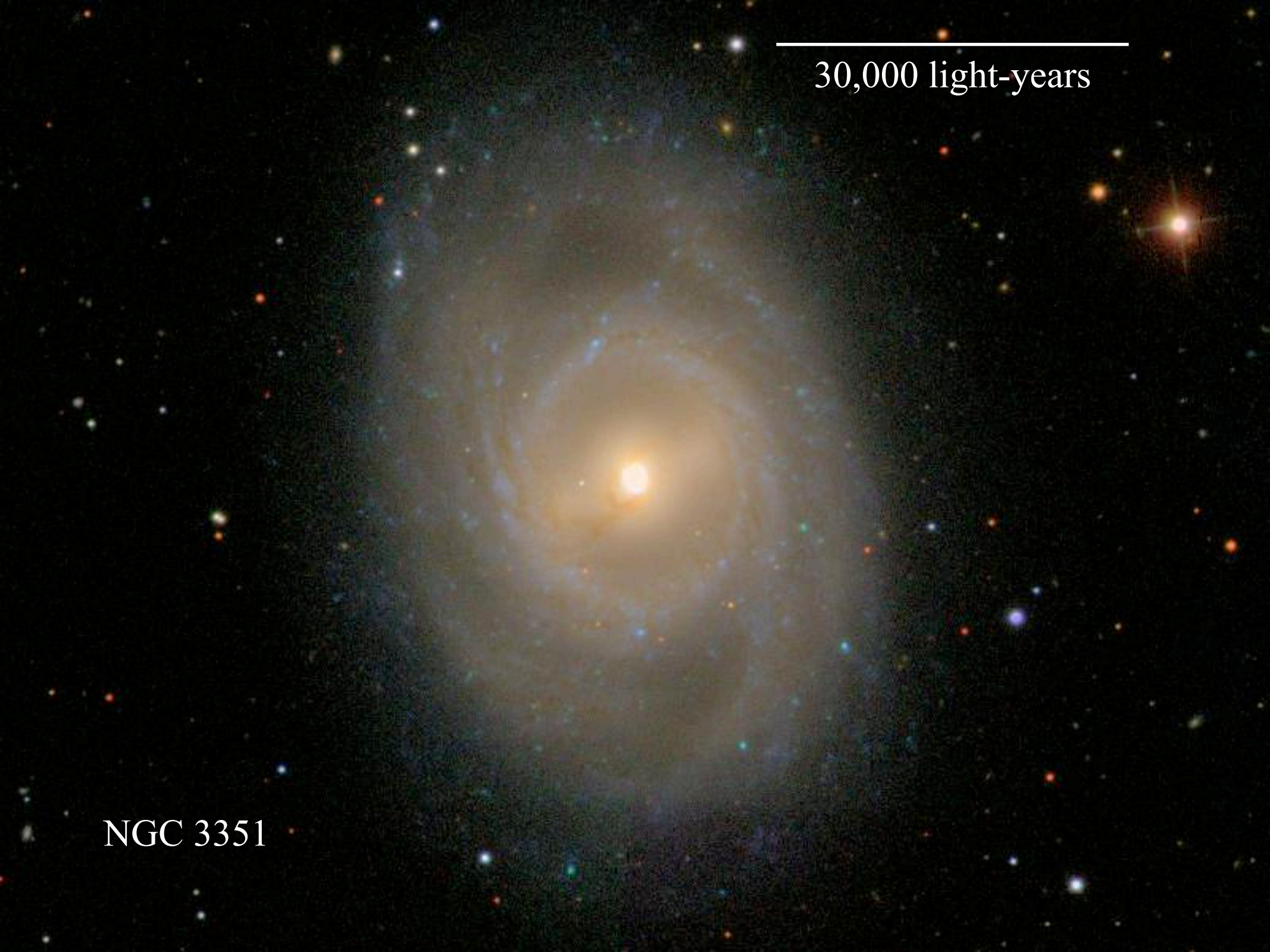
Scale model: if the Milky Way filled the Bay Area. neighboring stars would be about 10 feet apart (100 billion of them!)

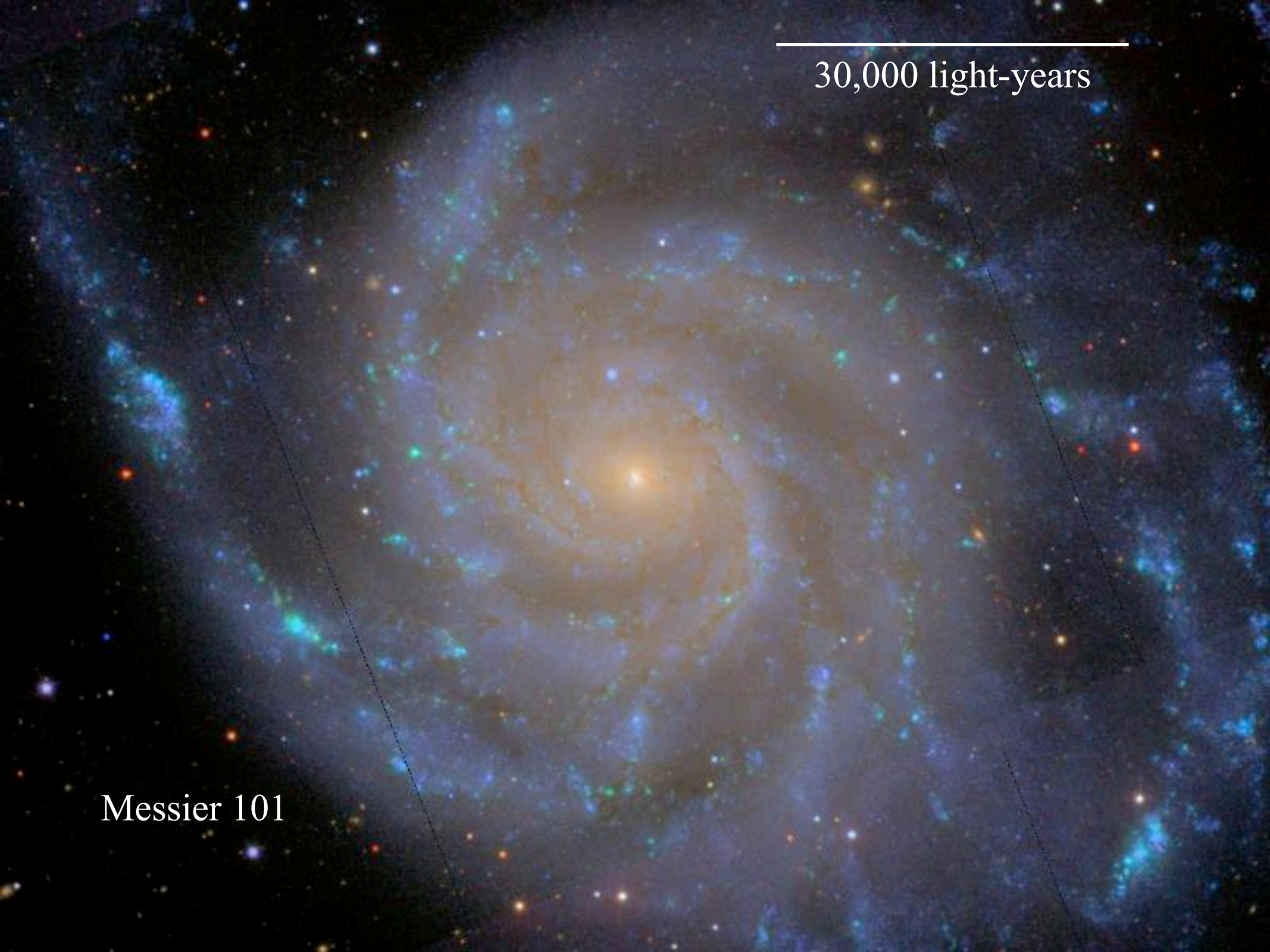
On this scale, the Sun - Neptune separation would be 5 sheets of paper (and Sun - Earth is 30 times smaller than that, a gnat's eyebrow).

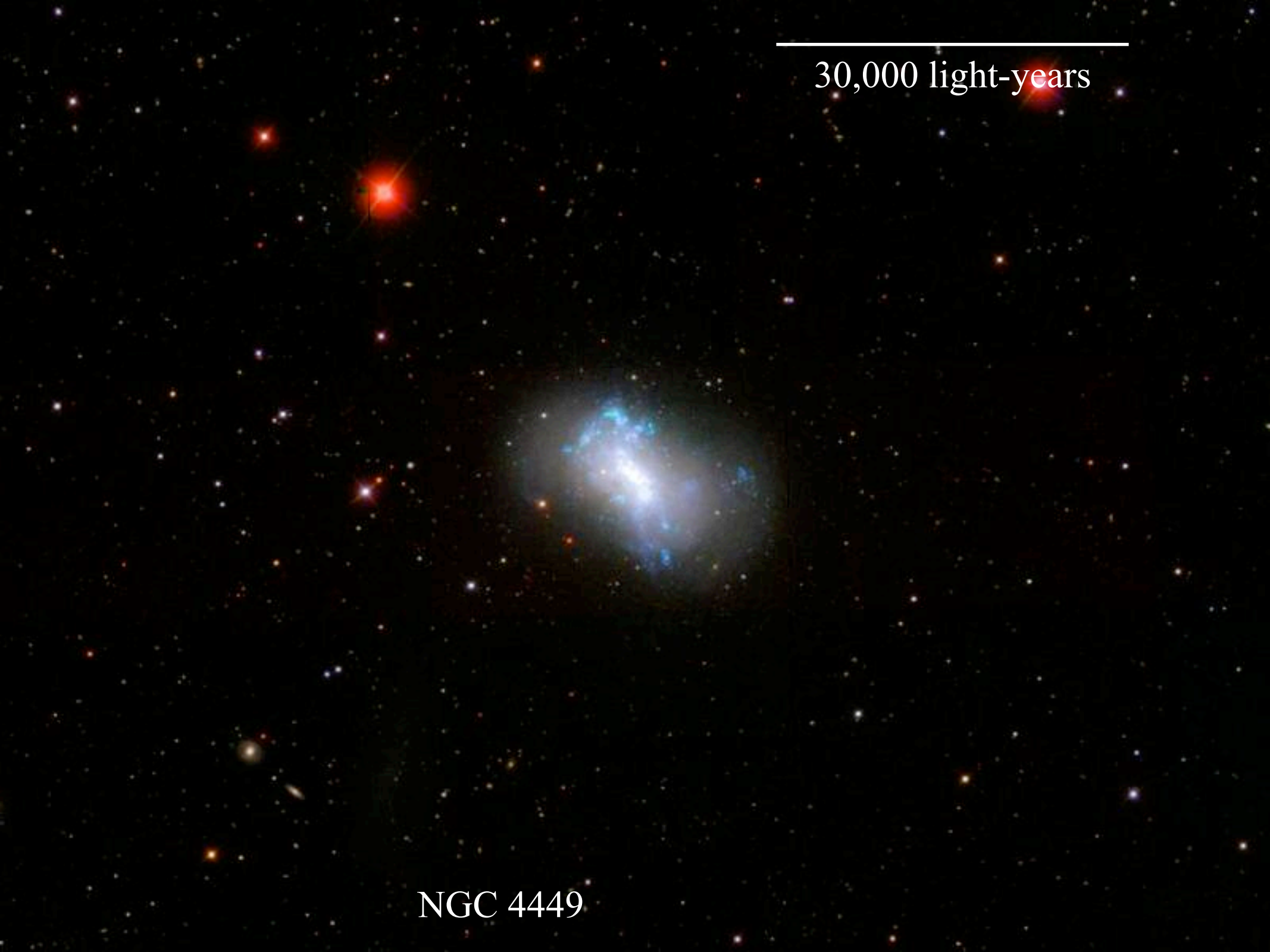

group of galaxies in Leo

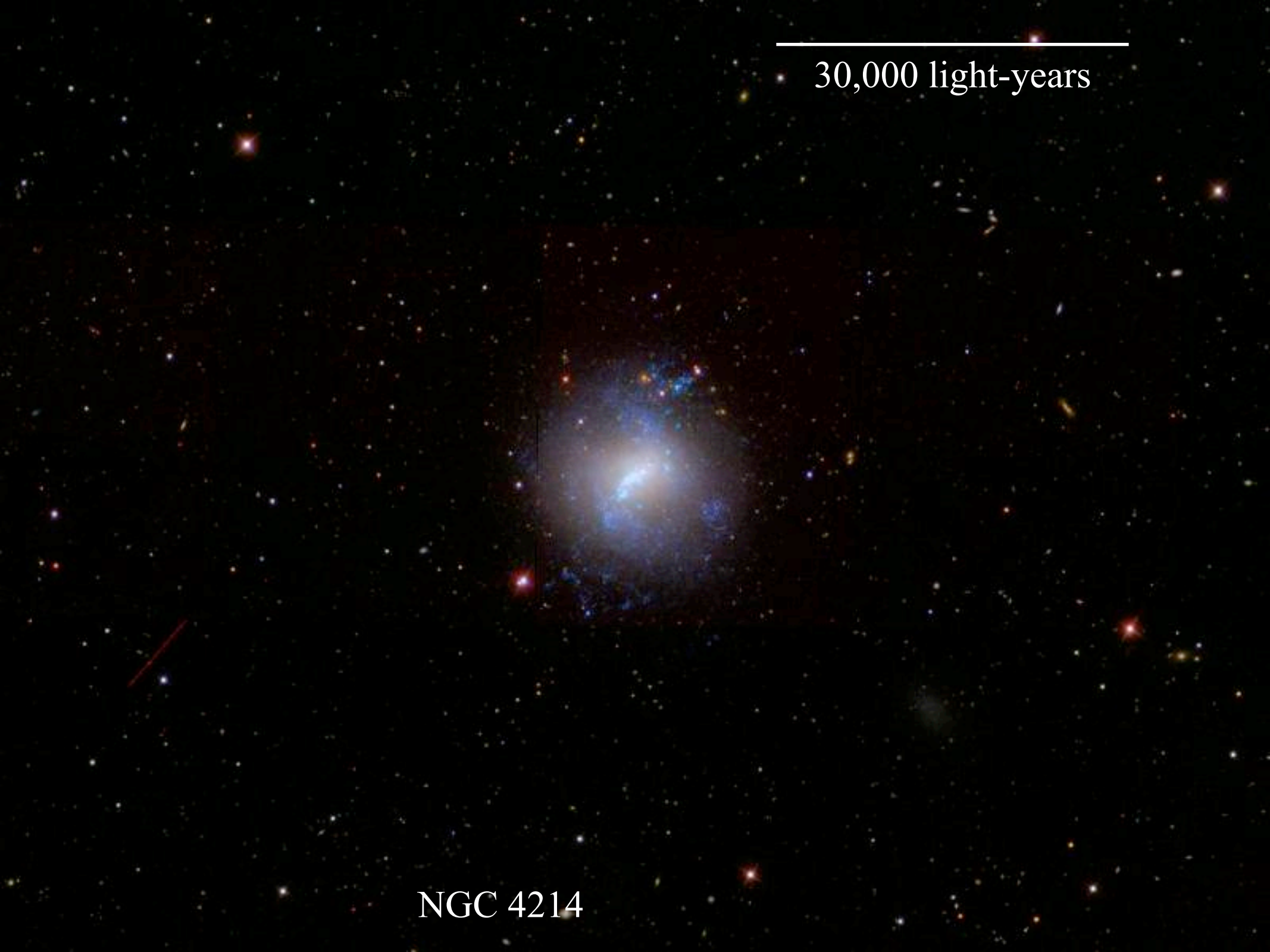

30,000 light-years
NGC 3384 & NGC 3379

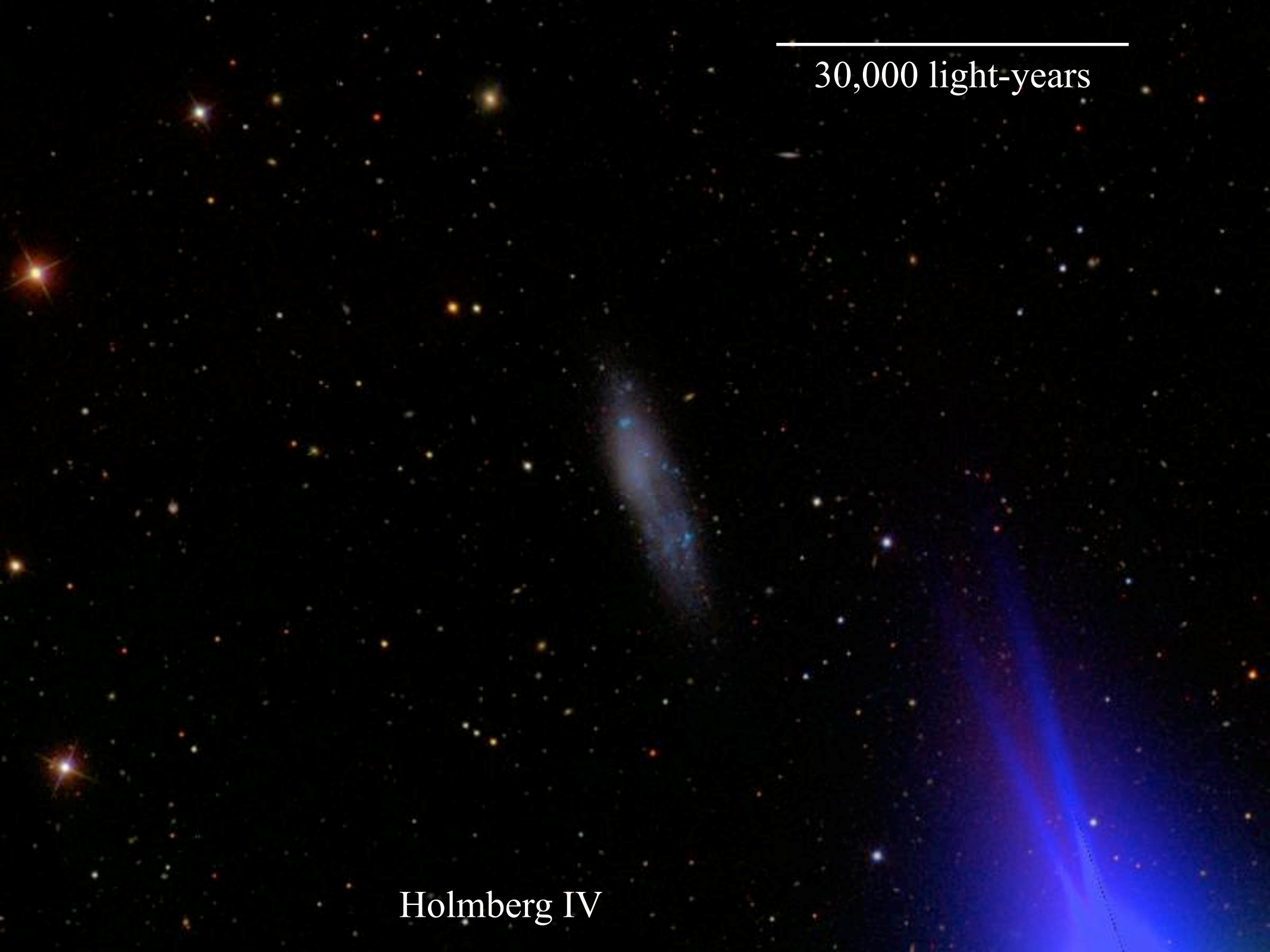

30,000 light-years
NGC 3368 = Messier 96

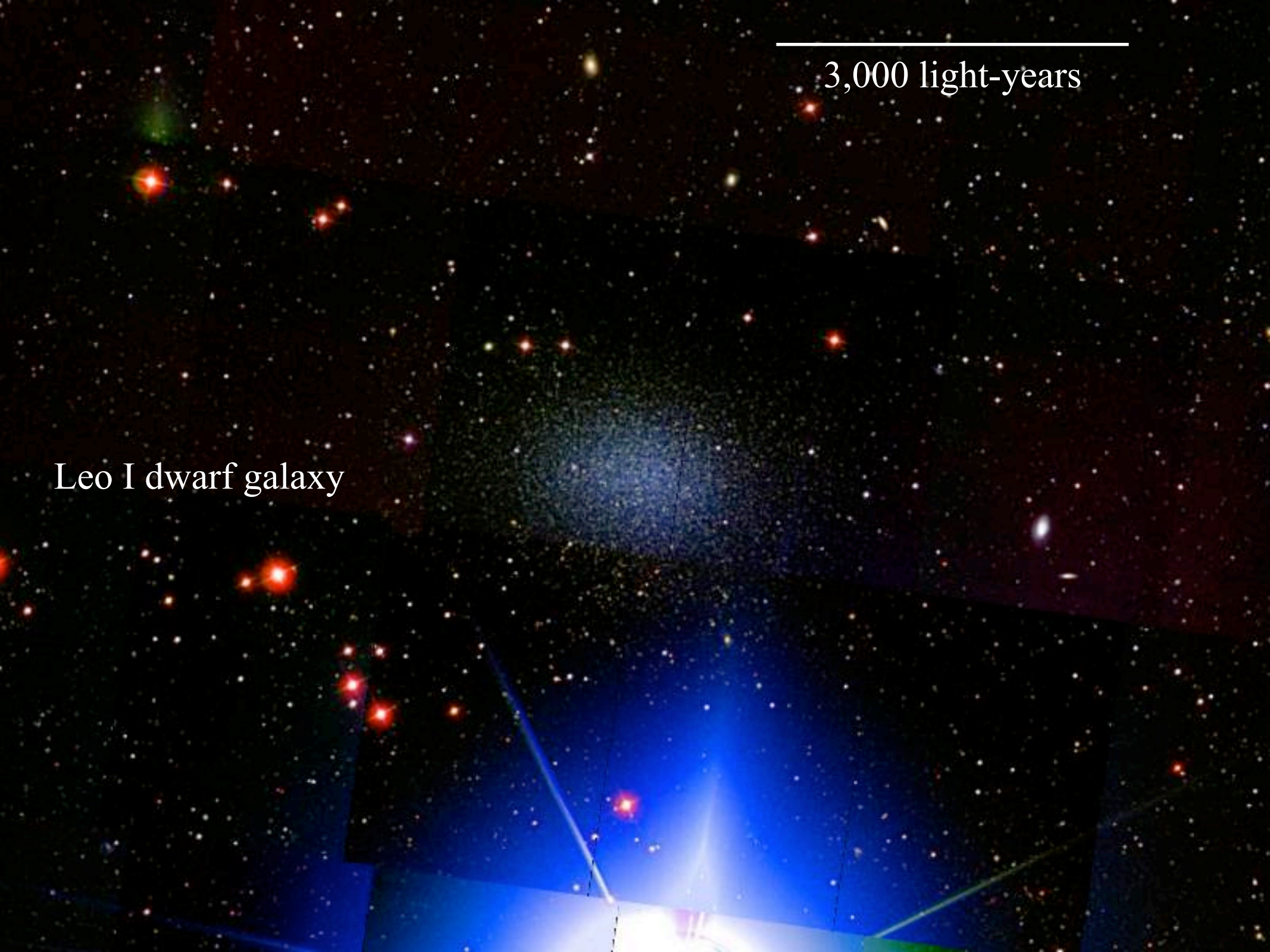

30,000 light-years
NGC 3351


30,000 light-years
Messier 101


30,000 light-years
NGC 4449


30,000 light-years
NGC 4214

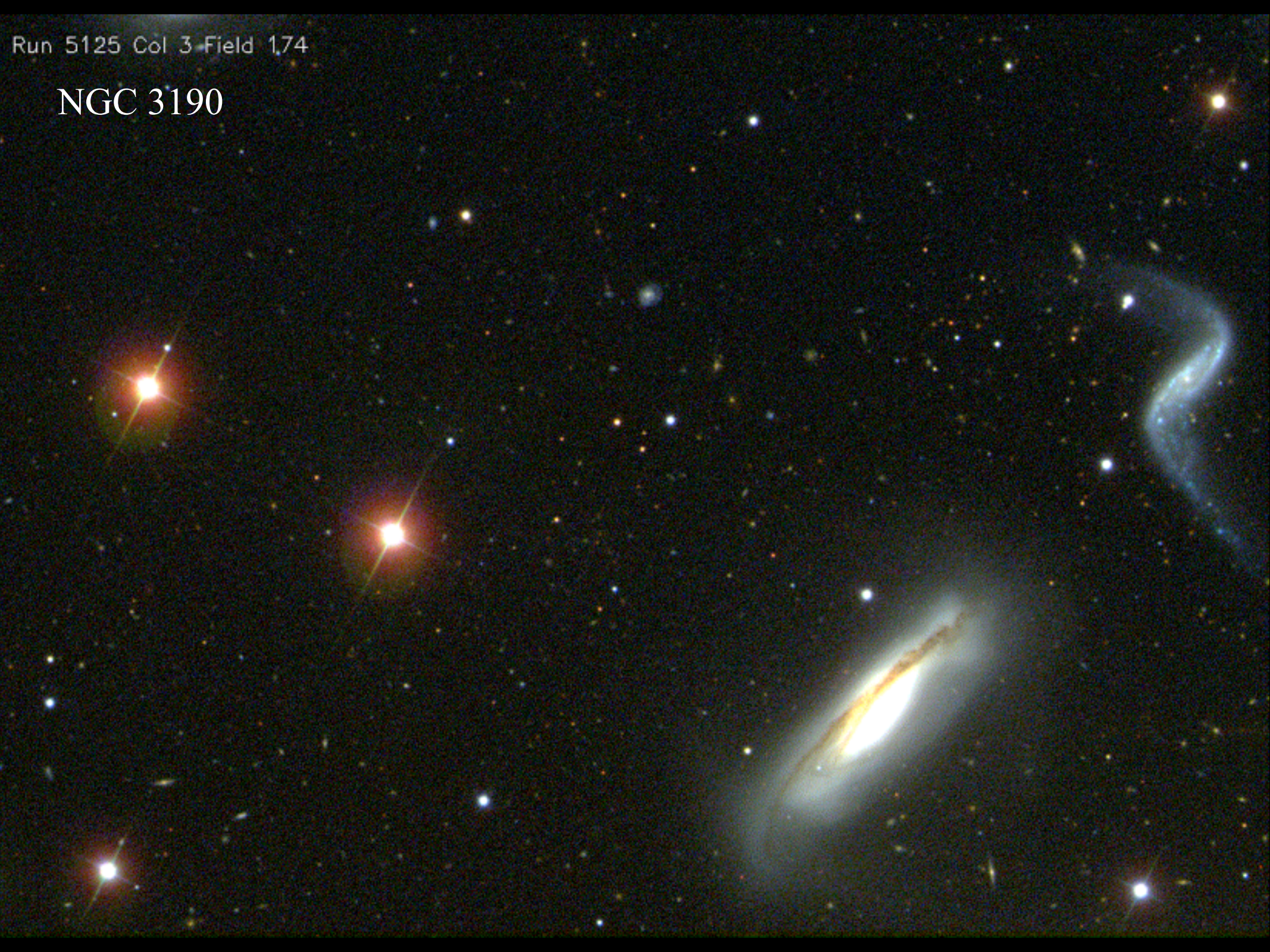

30,000 light-years
Holmberg IV

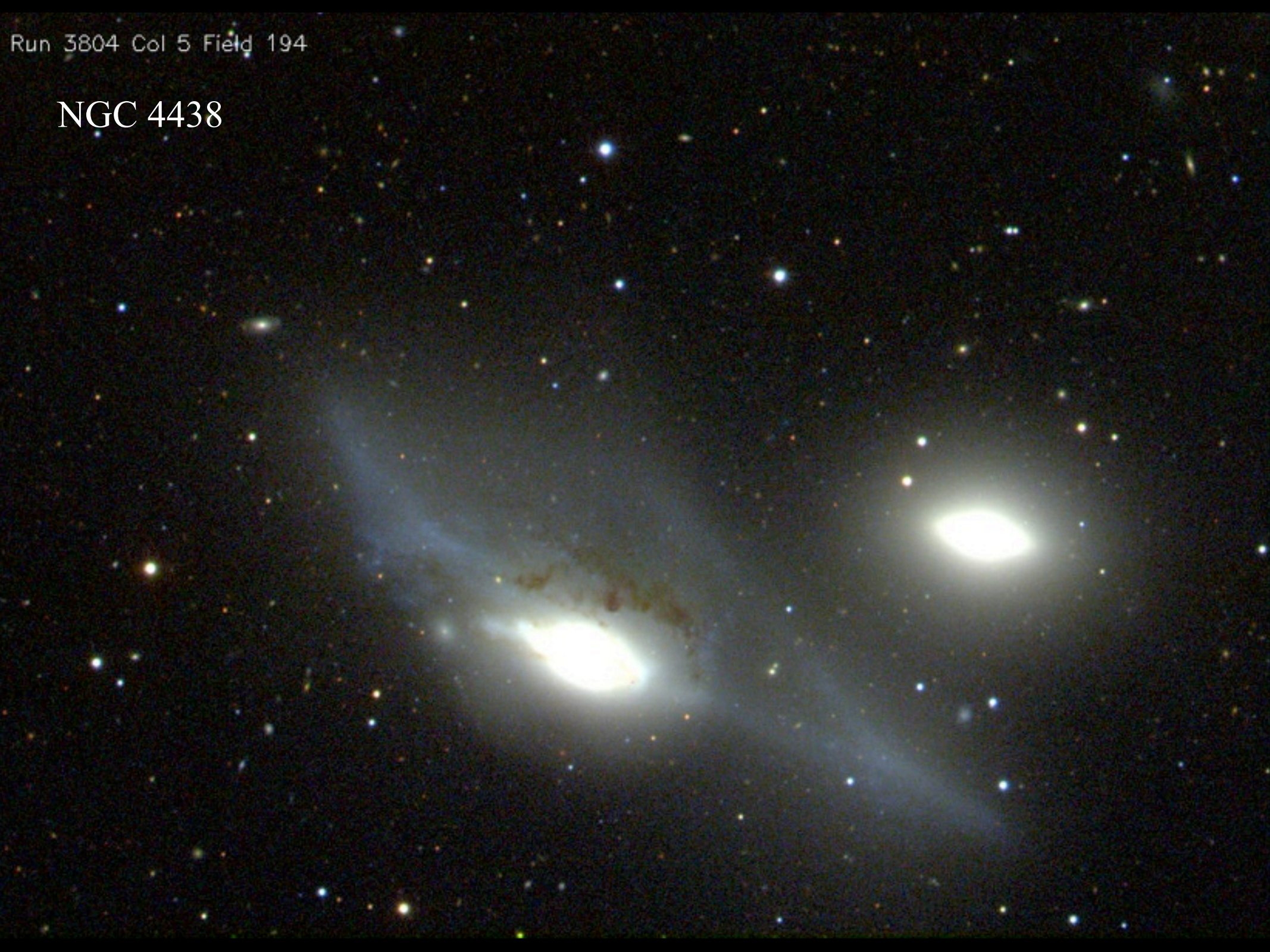

3,000 light-years
Leo I dwarf galaxy


Run 2078 Col 1 Field 157
NGC 5218 & Arp 104
galaxy collisions take a few hundred million years, start to finish

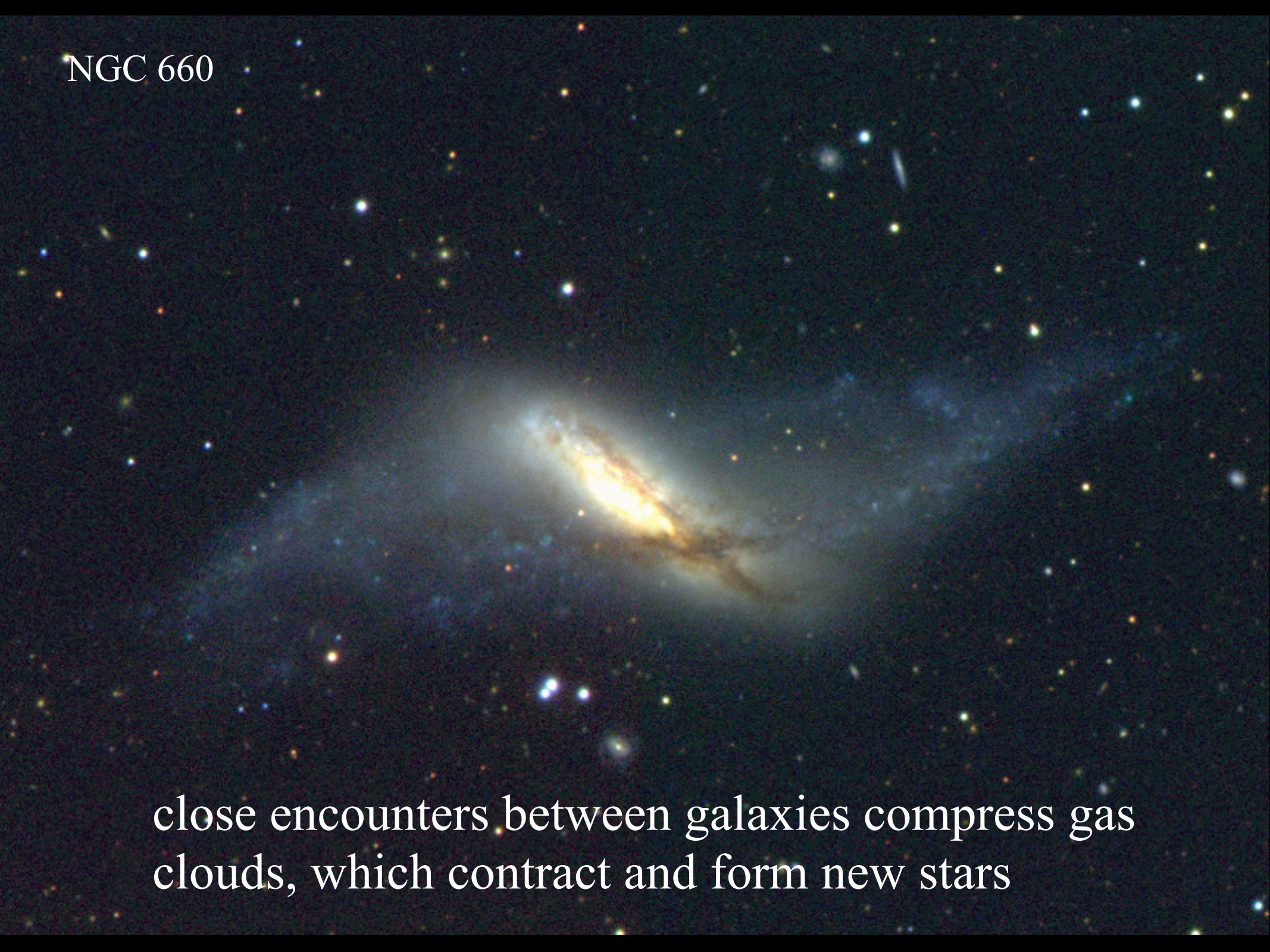
John Dubinski's computer simulation of the future collision between the Milky Way and Messier 31:

http://www.galaxydynamics.org/spiral_metamorphosis.html

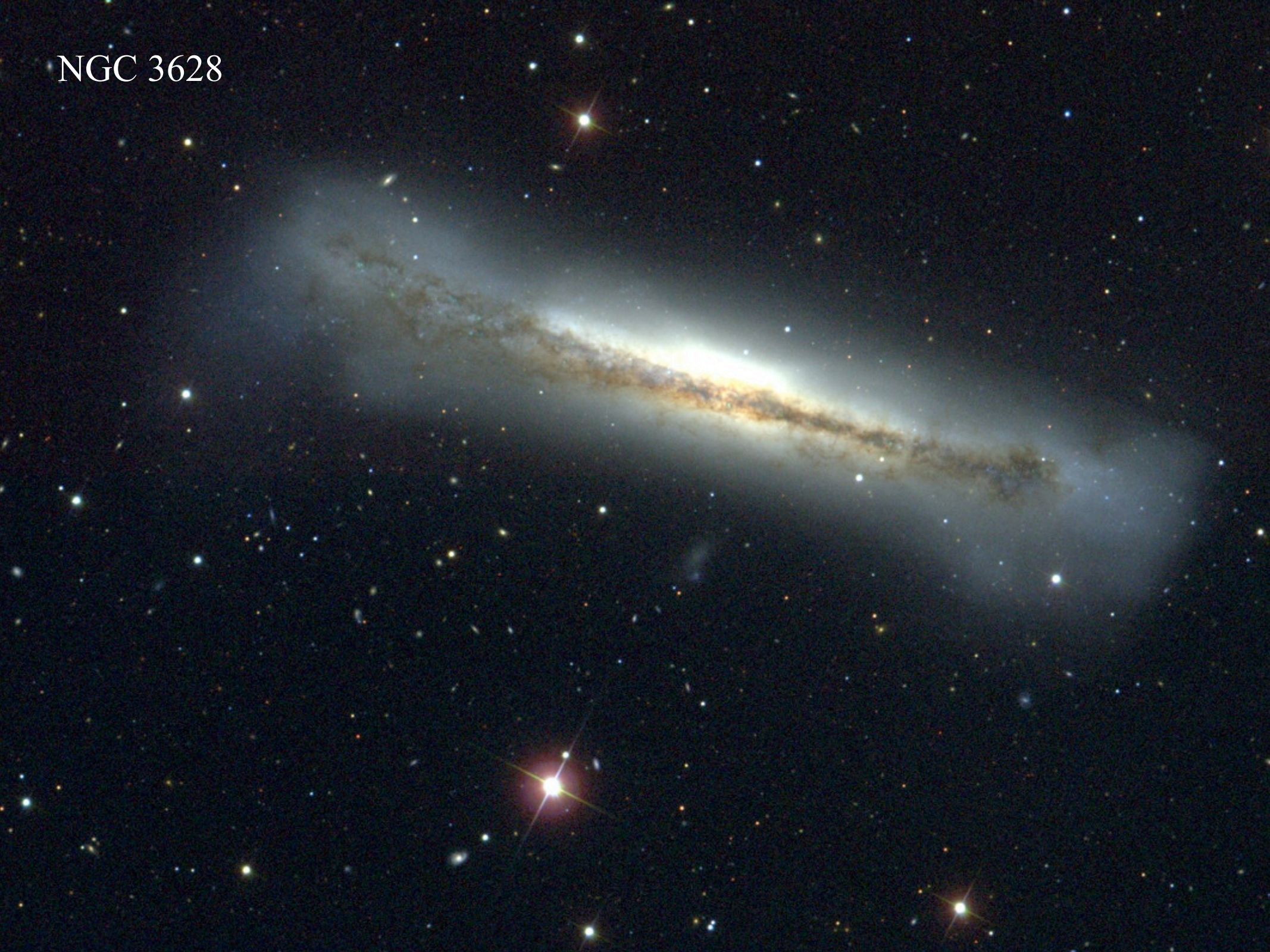

Run 5125 Col 3 Field 174
NGC 3190

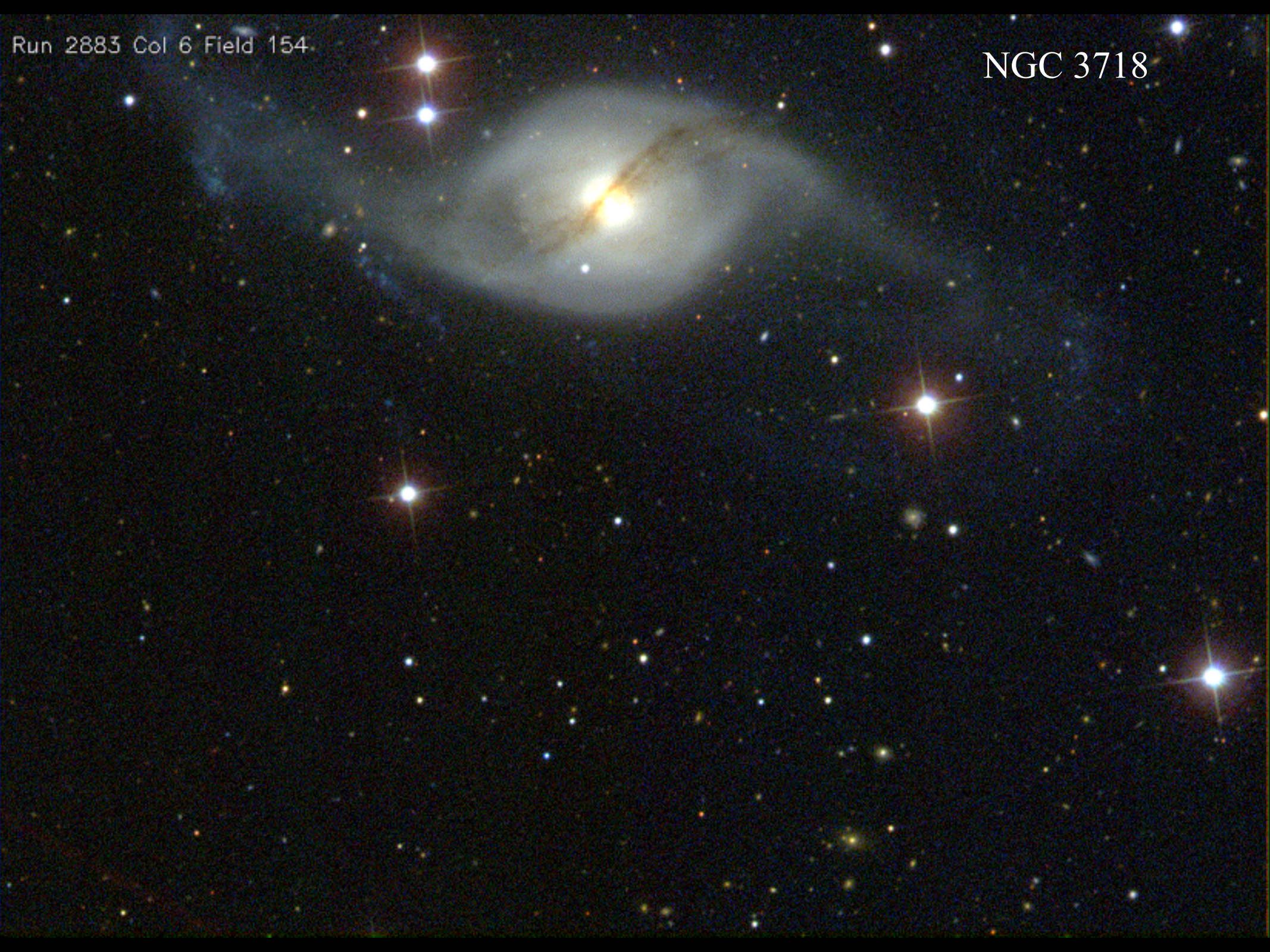

Run 3804 Col 5 Field 194
NGC 4438

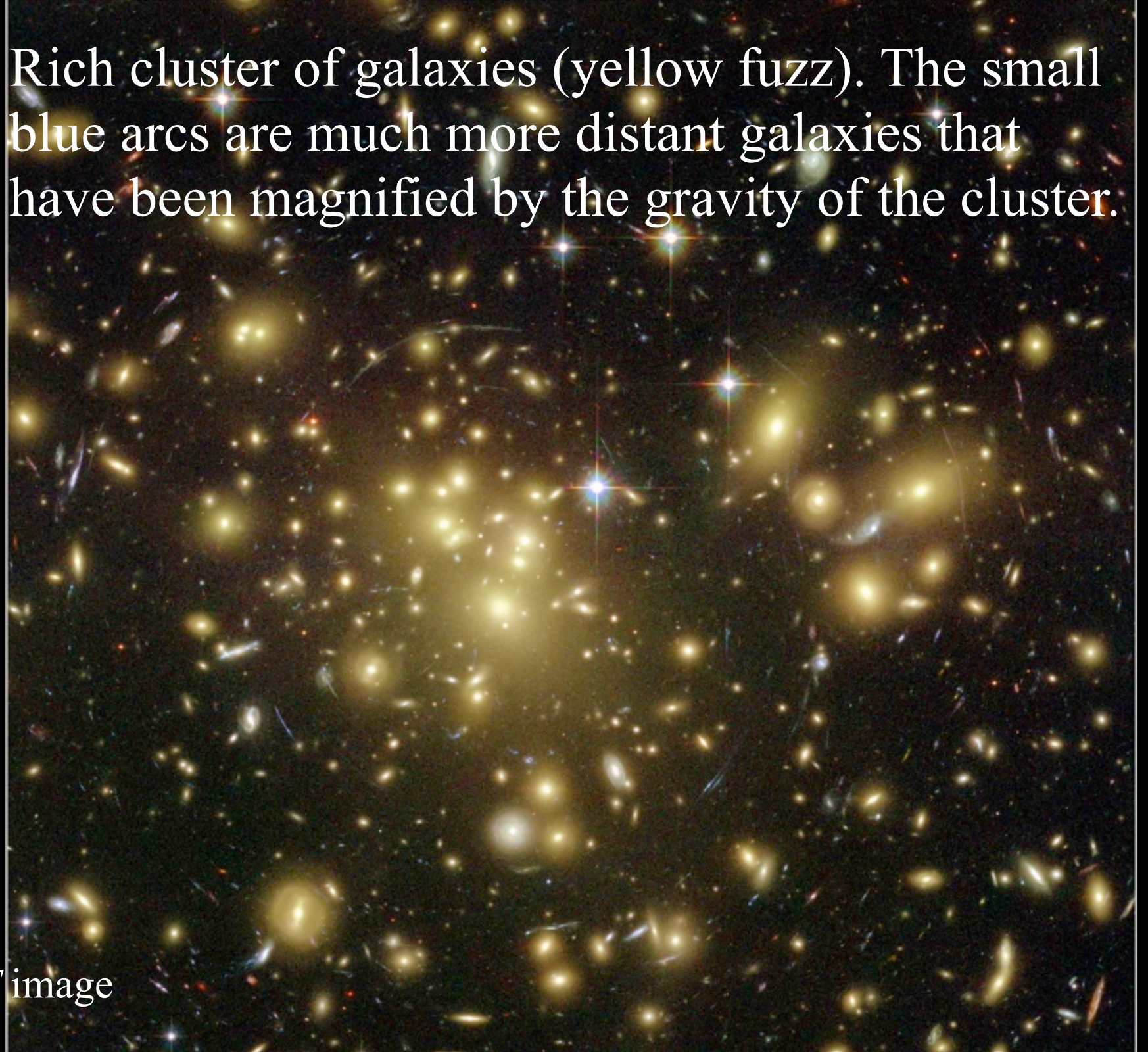

Arp 94



close encounters between galaxies compress gas clouds, which contract and form new stars


NGC 3628

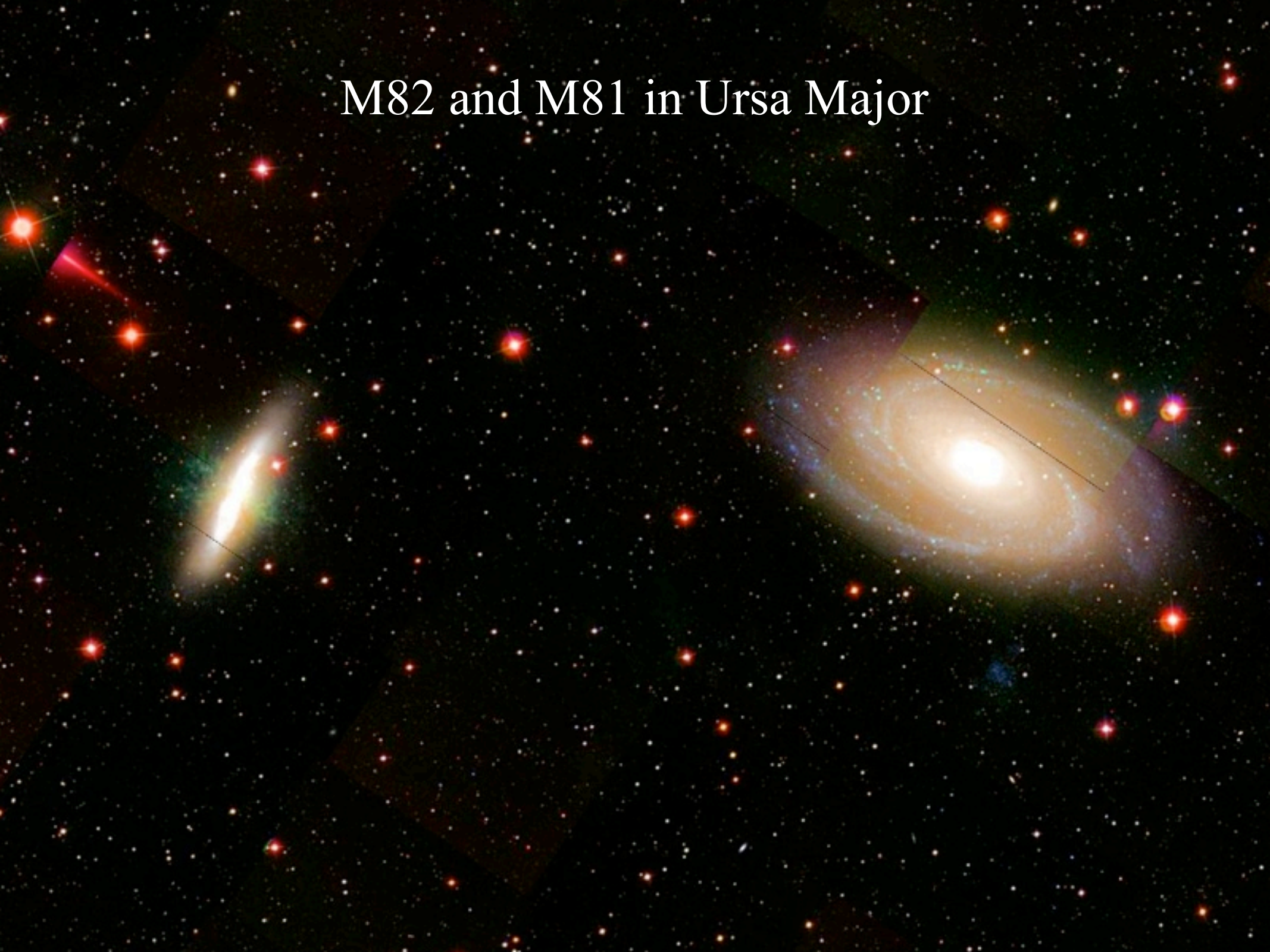

Run 2883 Col 6 Field 154
NGC 3718

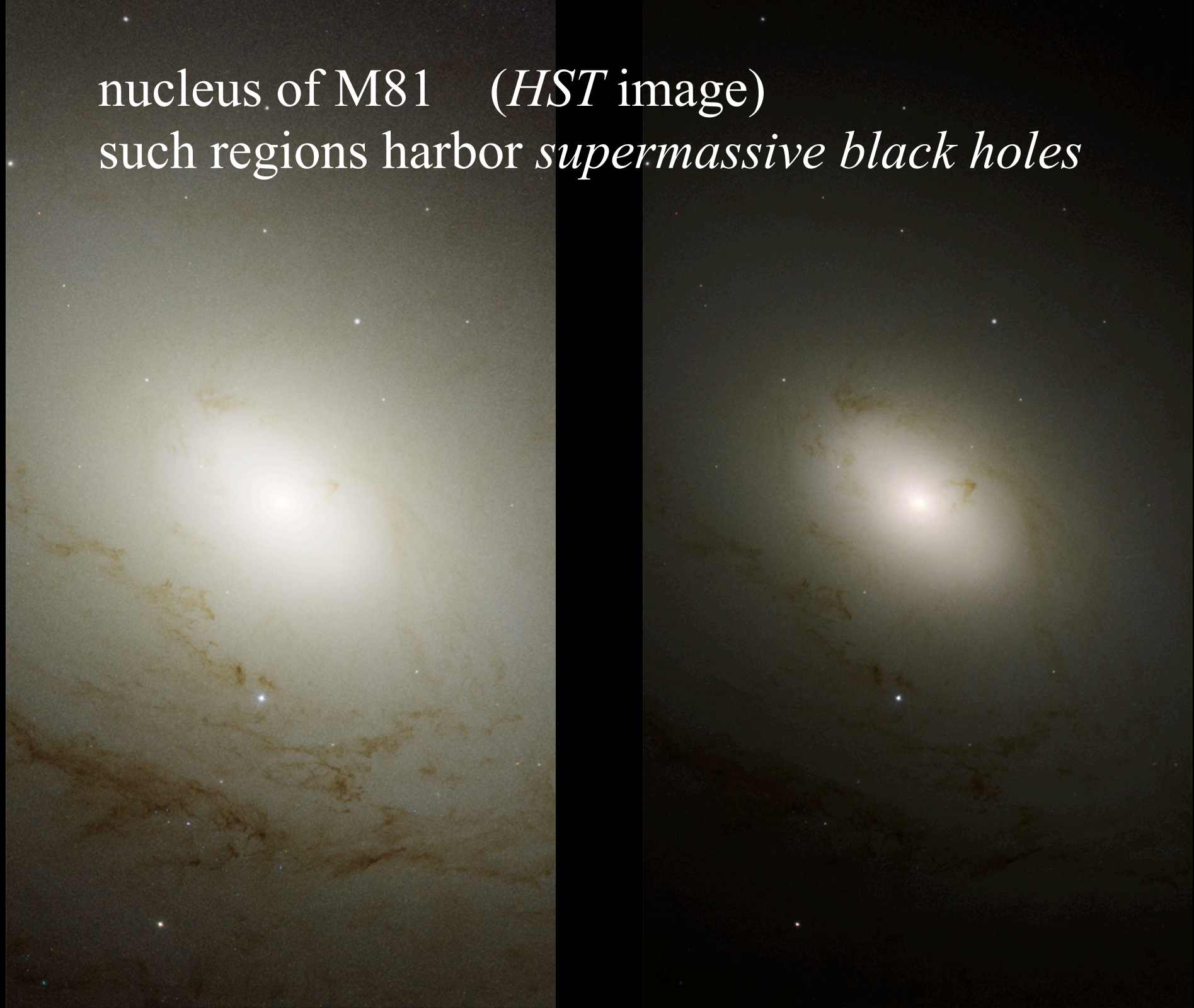


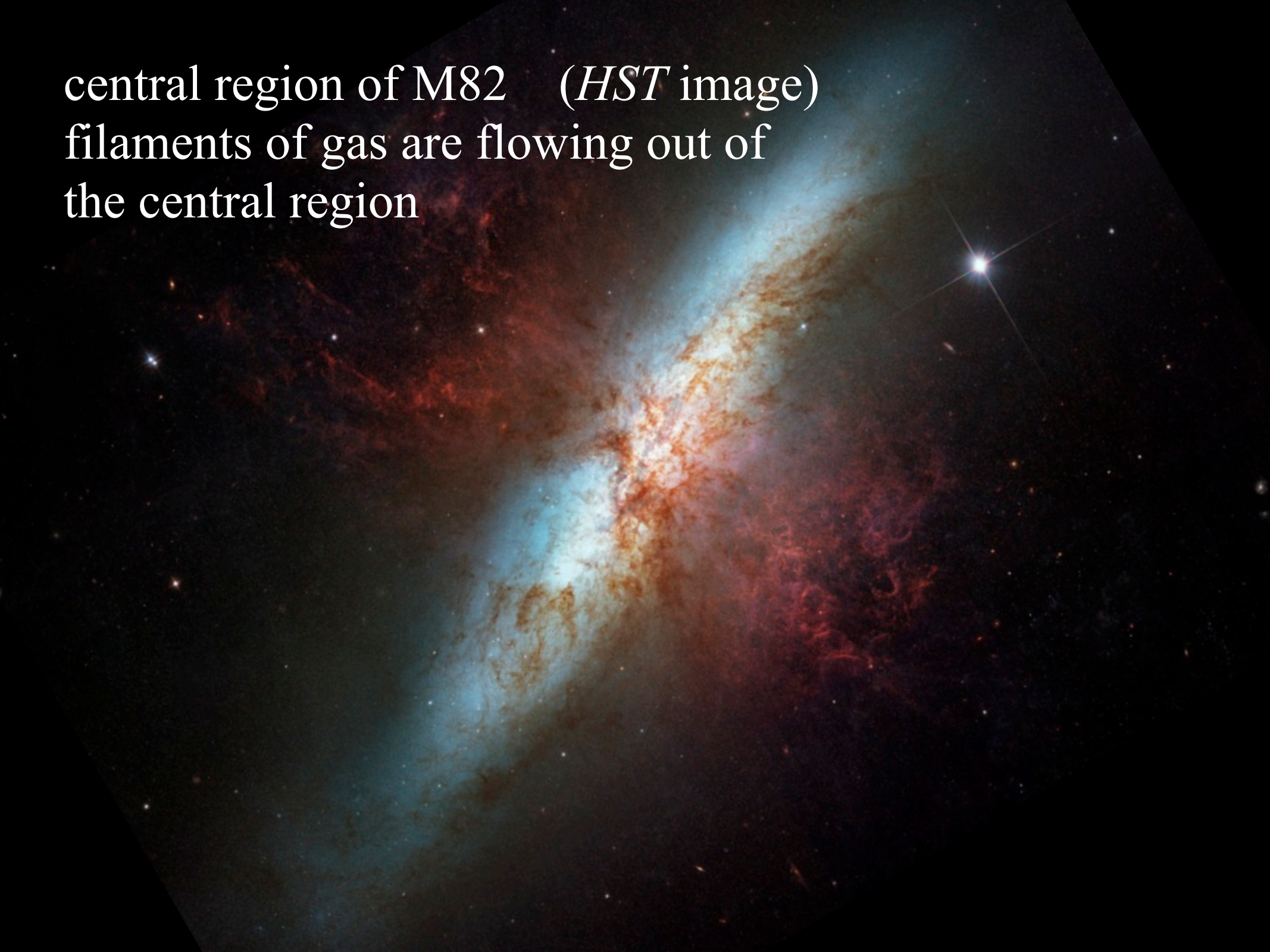
Rich cluster of galaxies (yellow fuzz). The small blue arcs are much more distant galaxies that have been magnified by the gravity of the cluster.

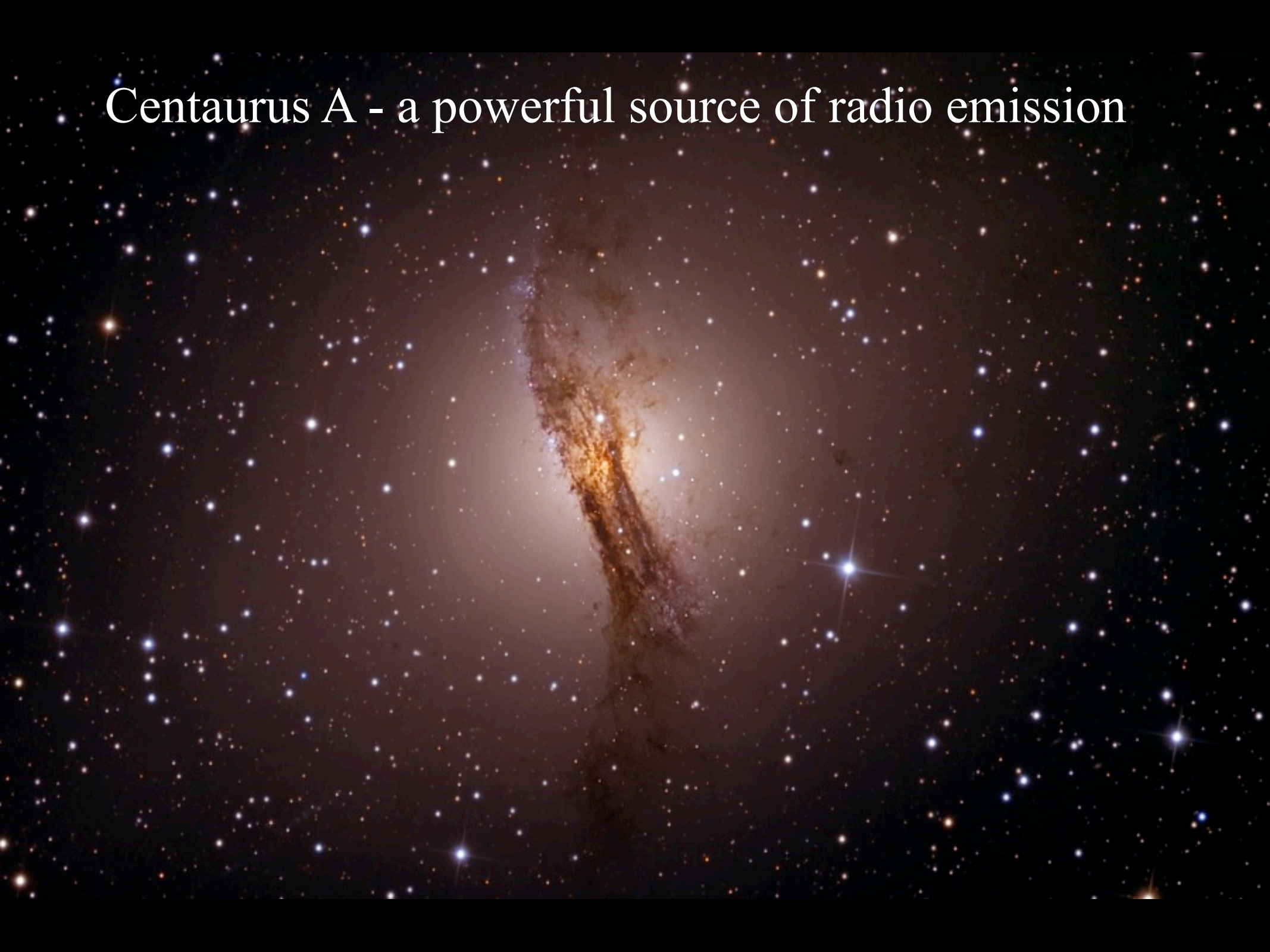
HST image


The more mass, the more magnification:
we can use these “gravitational lenses” to
determine the total mass of the cluster.


M82 and M81 in Ursa Major

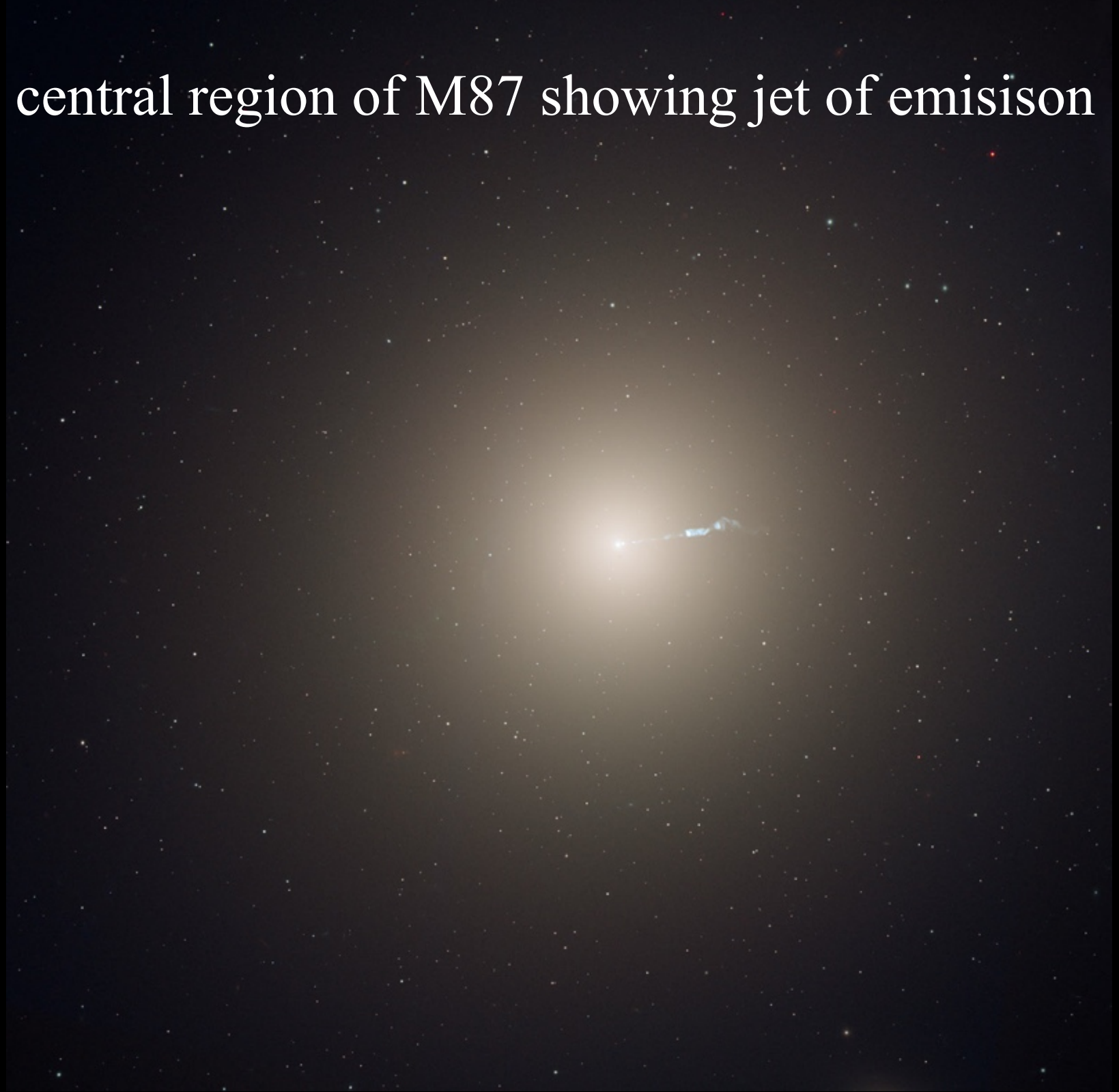

nucleus of M81 (*HST* image)
such regions harbor *supermassive black holes*

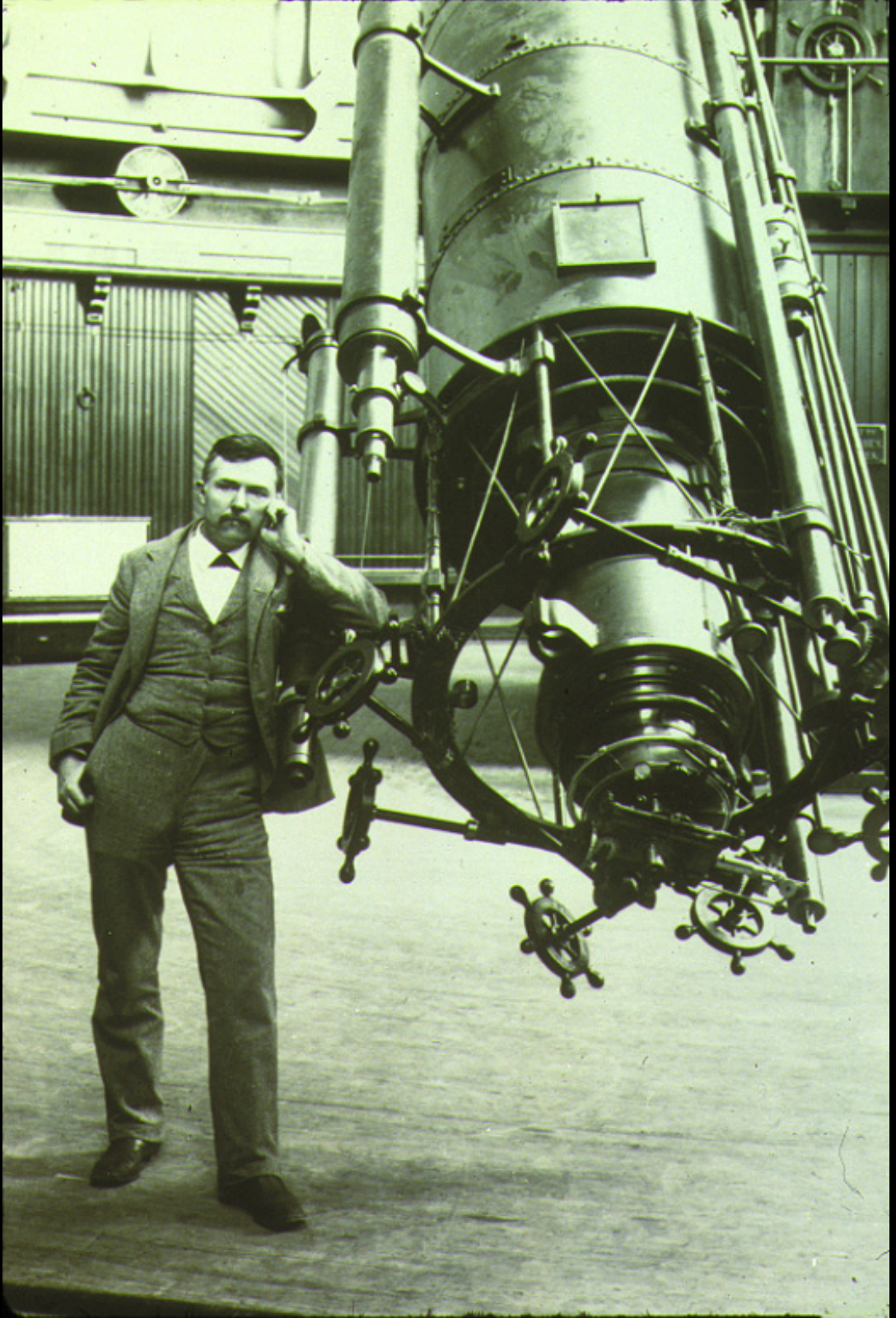

central region of M82 (*HST* image)
filaments of gas are flowing out of
the central region


Centaurus A - a powerful source of radio emission


M87 - central giant in the Virgo cluster of galaxies

central region of M87 showing jet of emisison

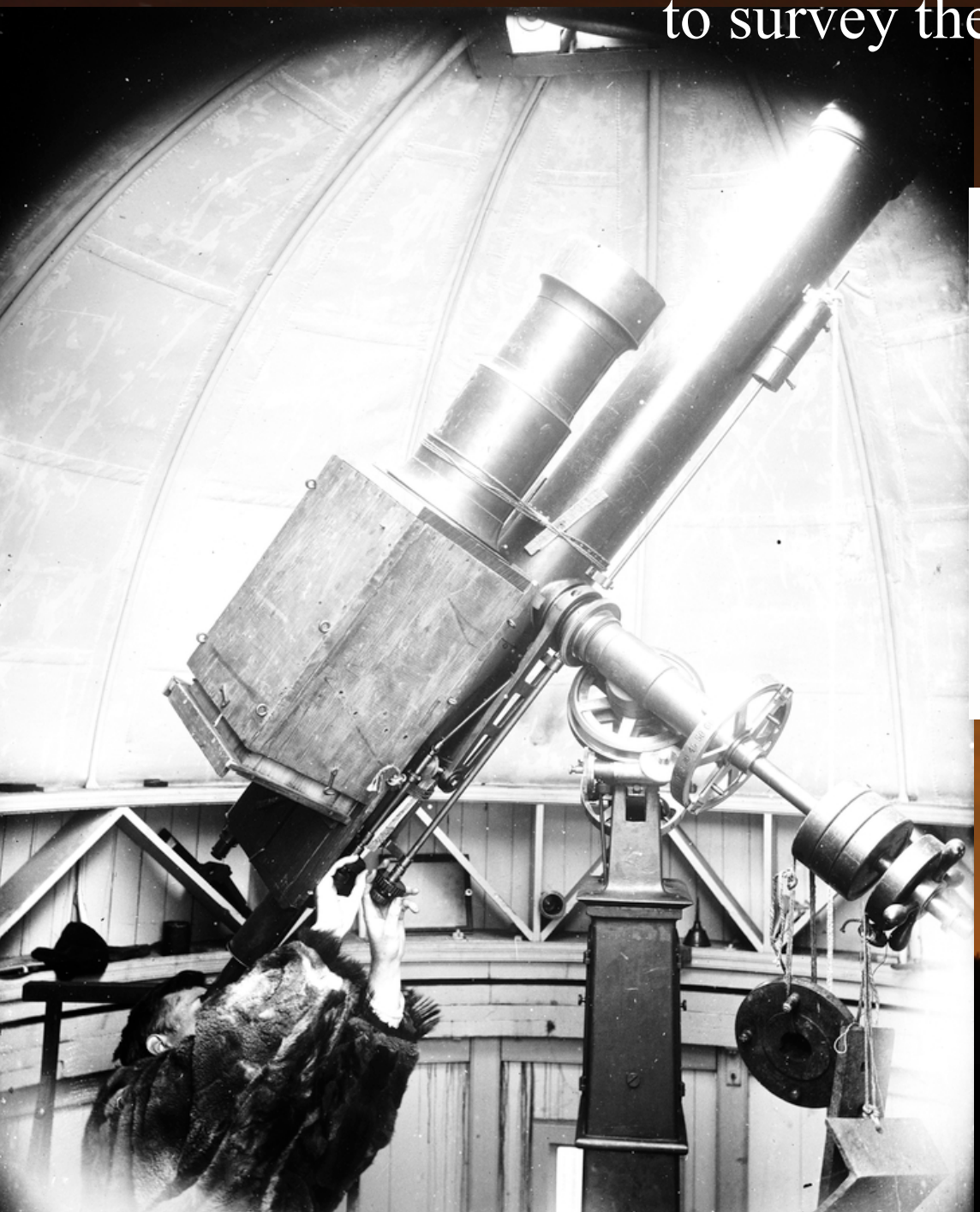


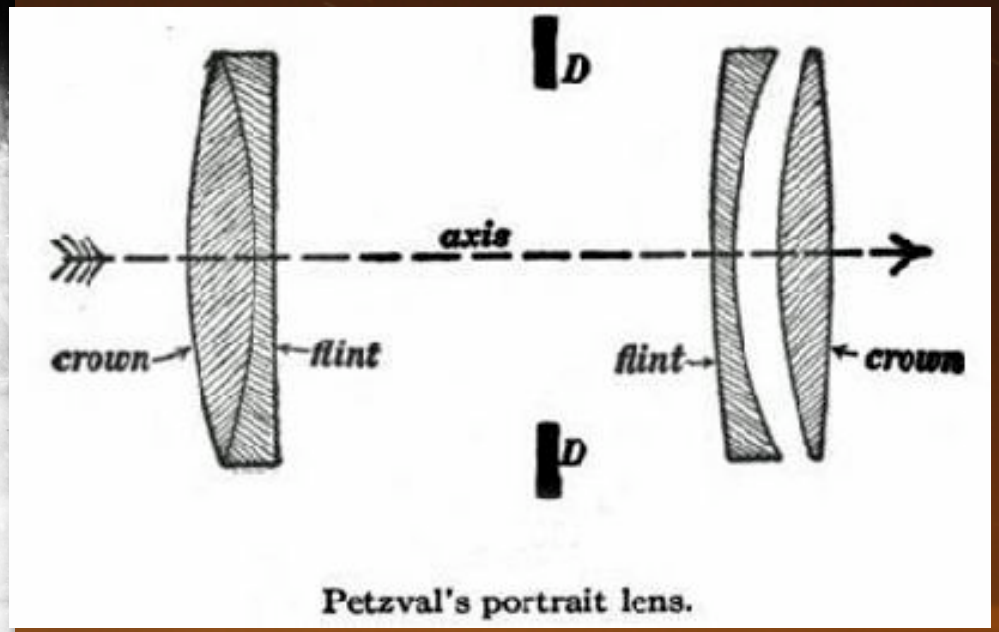


Edward Emerson Barnard
1857 - 1923

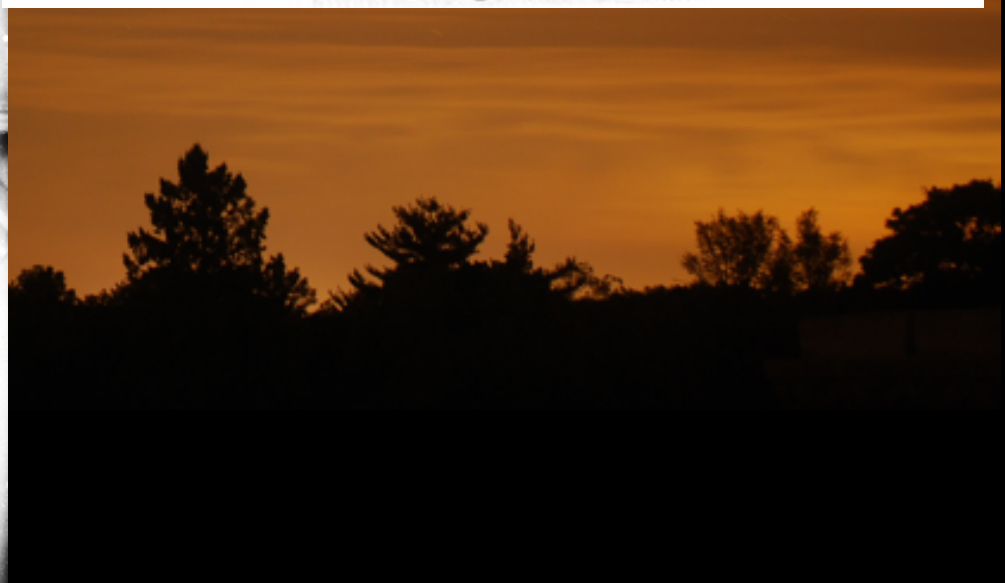
- discovered Amalthea, fifth satellite of Jupiter
- numerous comets
- Barnard's star
- map of the Milky Way

Barnard used a photographer's portrait lens to survey the Milky Way in the 1890's





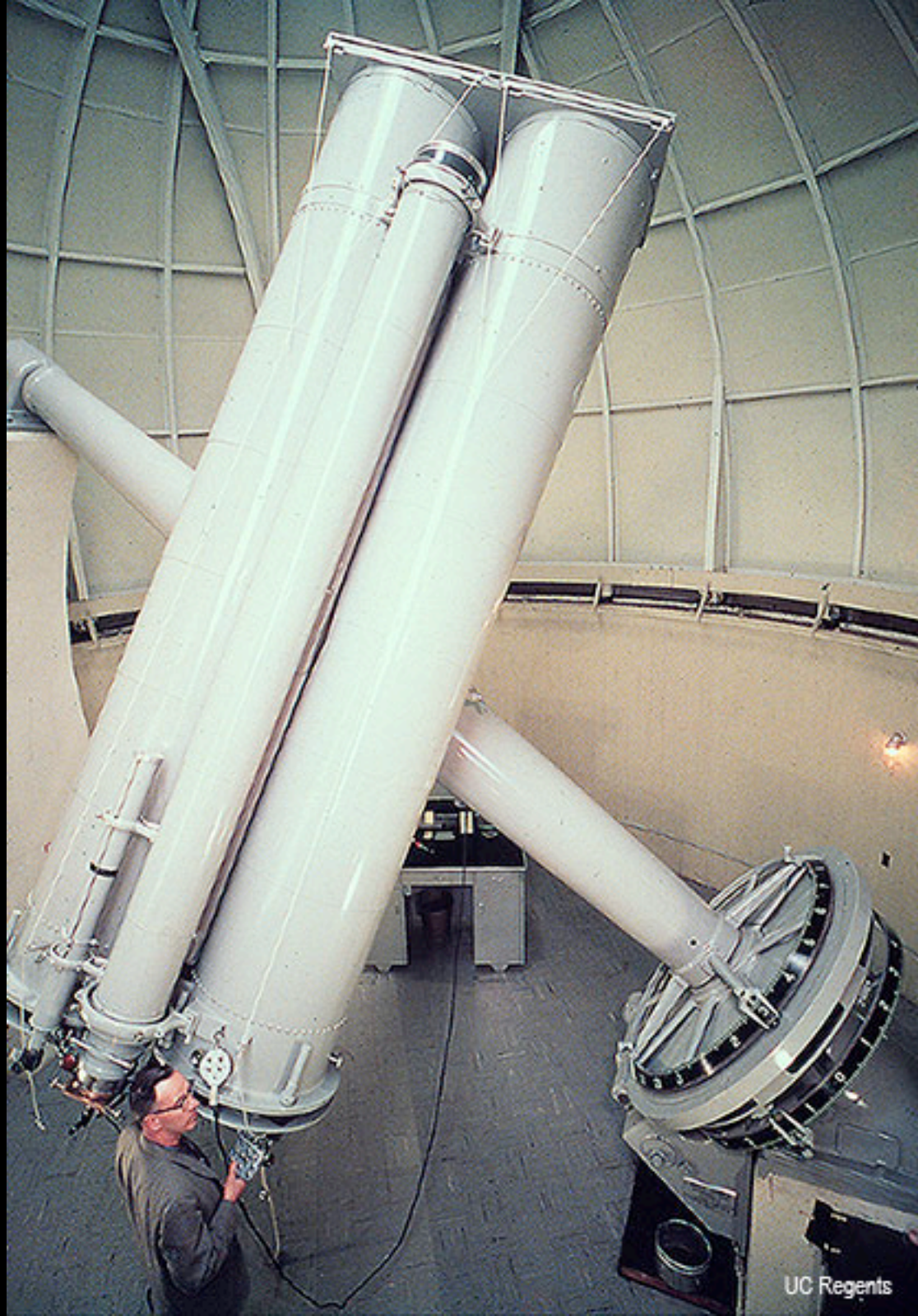
Petzval's portrait lens.




An Atlas of the Milky Way
Publ. Lick Obs. vol XI 1913

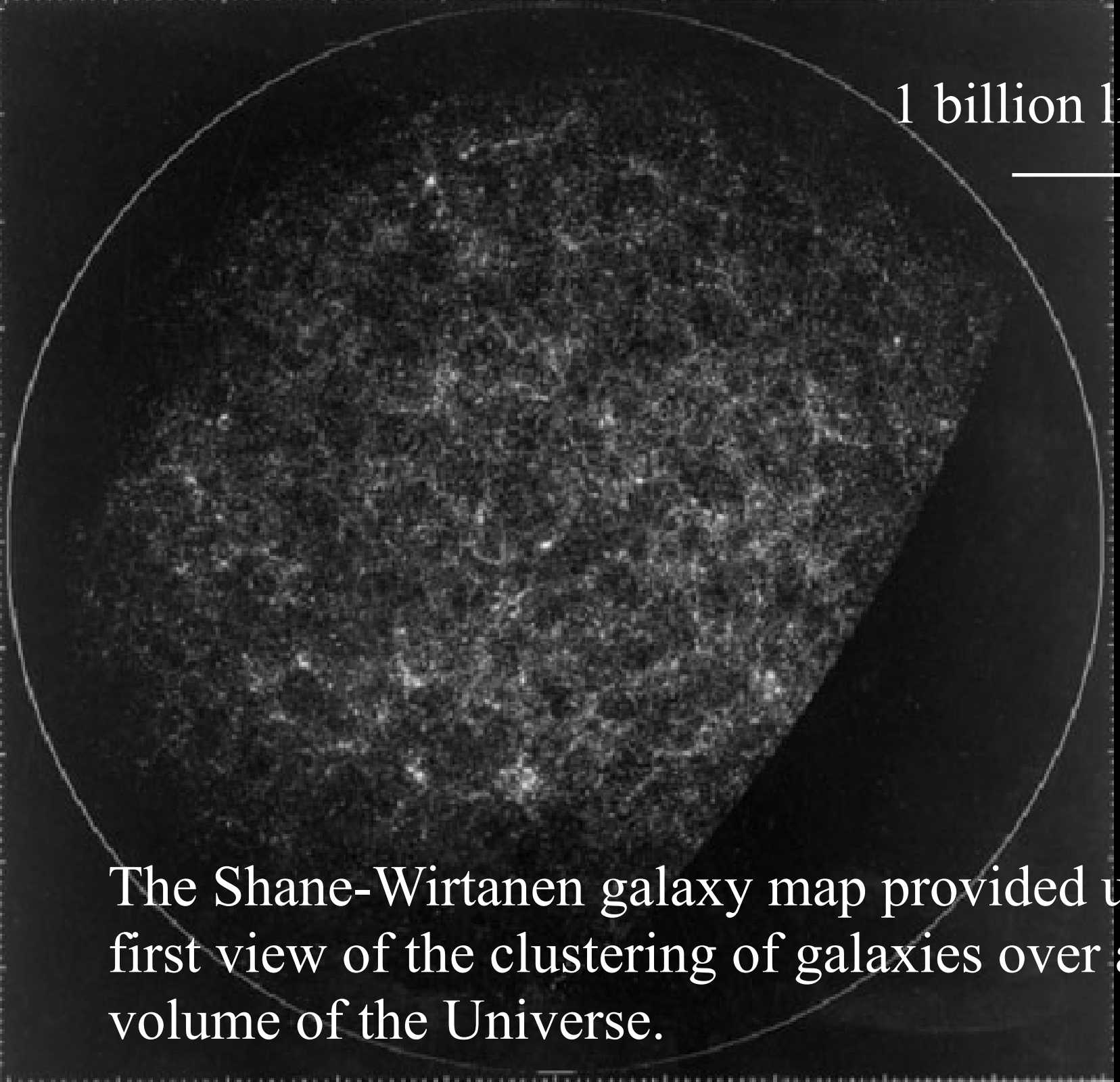
The Carnegie 20-inch double astrograph also made an atlas of the sky.

Carl Wirtanen and Donald Shane counted galaxies on the glass plates - one million galaxies in total.

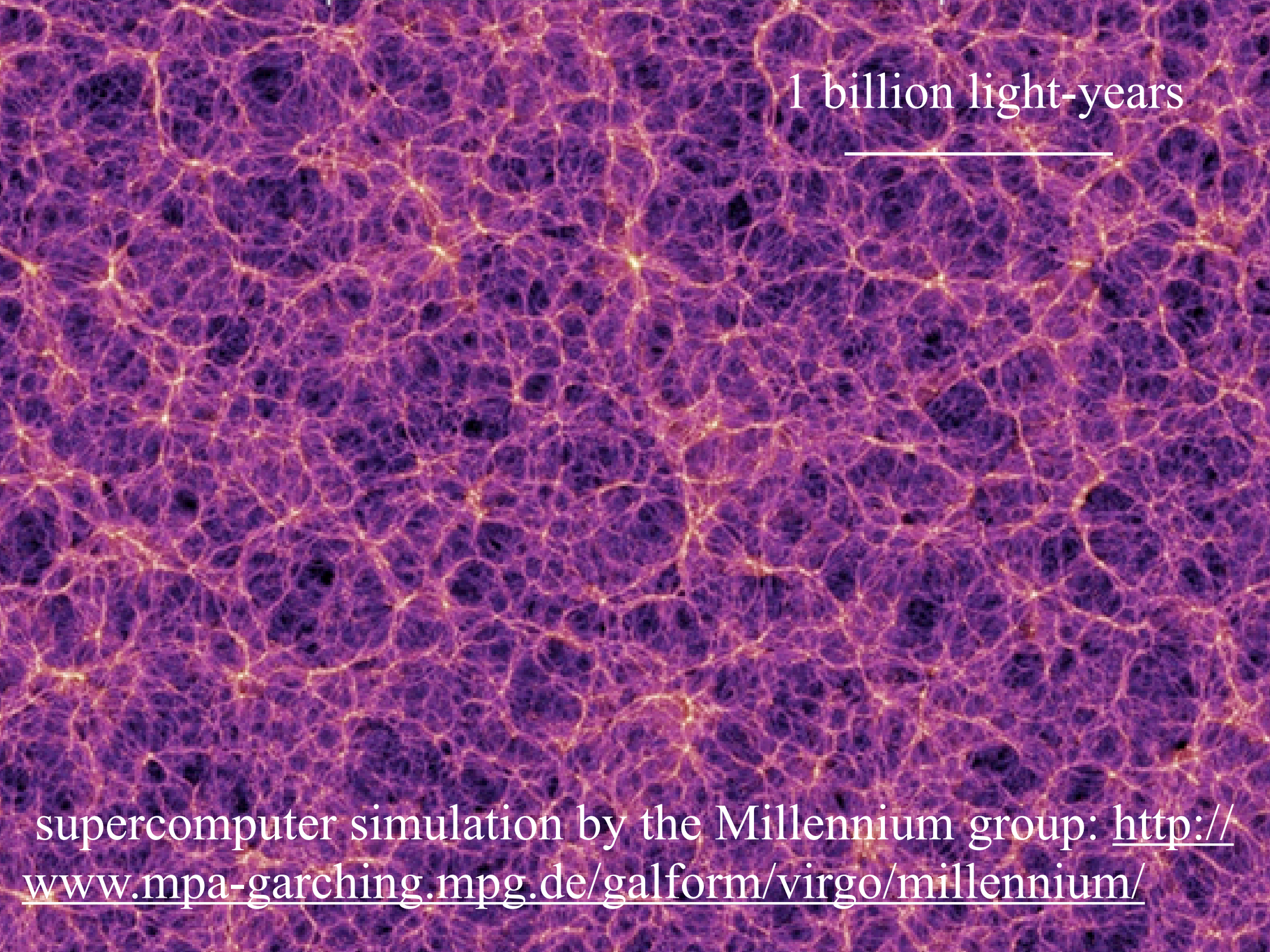


Charles Donald Shane
Mary Lea Shane
(about 1976)

Carl Wirtanen
Kate Gordon
Edith Wirtanen
(about 1946)



The Shane-Wirtanen galaxy map provided us with the first view of the clustering of galaxies over a significant volume of the Universe.



supercomputer simulation by the Millennium group: http://www.mpa-garching.mpg.de/galform/virgo/millennium/

1941 Sky & Telescope: “Progress in Extragalactic Research” by Kate Gordon

maps of the distribution of galaxies show clustering up to large scales

elliptical galaxies are more frequently found in dense clusters

the observed colors of galaxies are diagnostic of the stars within them

there are two main types of supernovae (exploding stars)

galaxies move through space with random speeds of 200 miles per second

there is a velocity-distance relation, suggesting an origin 2 billion years ago

1941 Sky & Telescope: “Progress in Extragalactic Research” by Kate Gordon

velocities of galaxies inside clusters tell us about the origin and mass of clusters

the mass of a galaxy can be determined from its rotation speed (10 to 100 billion times the mass of the Sun)

galaxies rotate in the sense that spiral arms trail

can we understand the variety of forms of galaxies by some kind of evolutionary process? do galaxies undergo some kind of internal instability? what are the effects of encounters between galaxies? permanent captures? spiral arms?