University of Chicago

Physical Sciences 120

The Origin of the Universe and How we Know

Lecture 4 - Our Galaxy III

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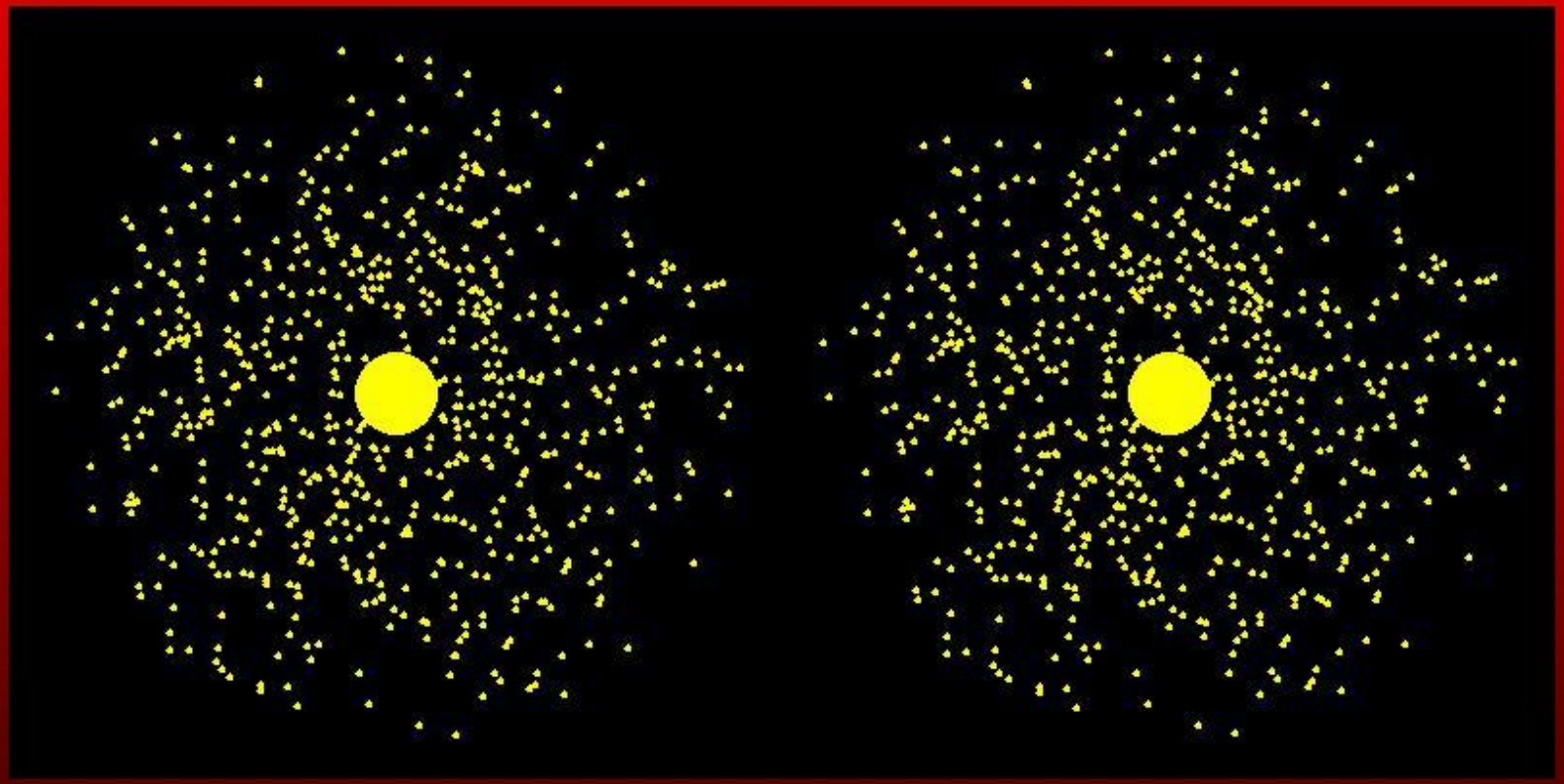
Thursday April 5 2007

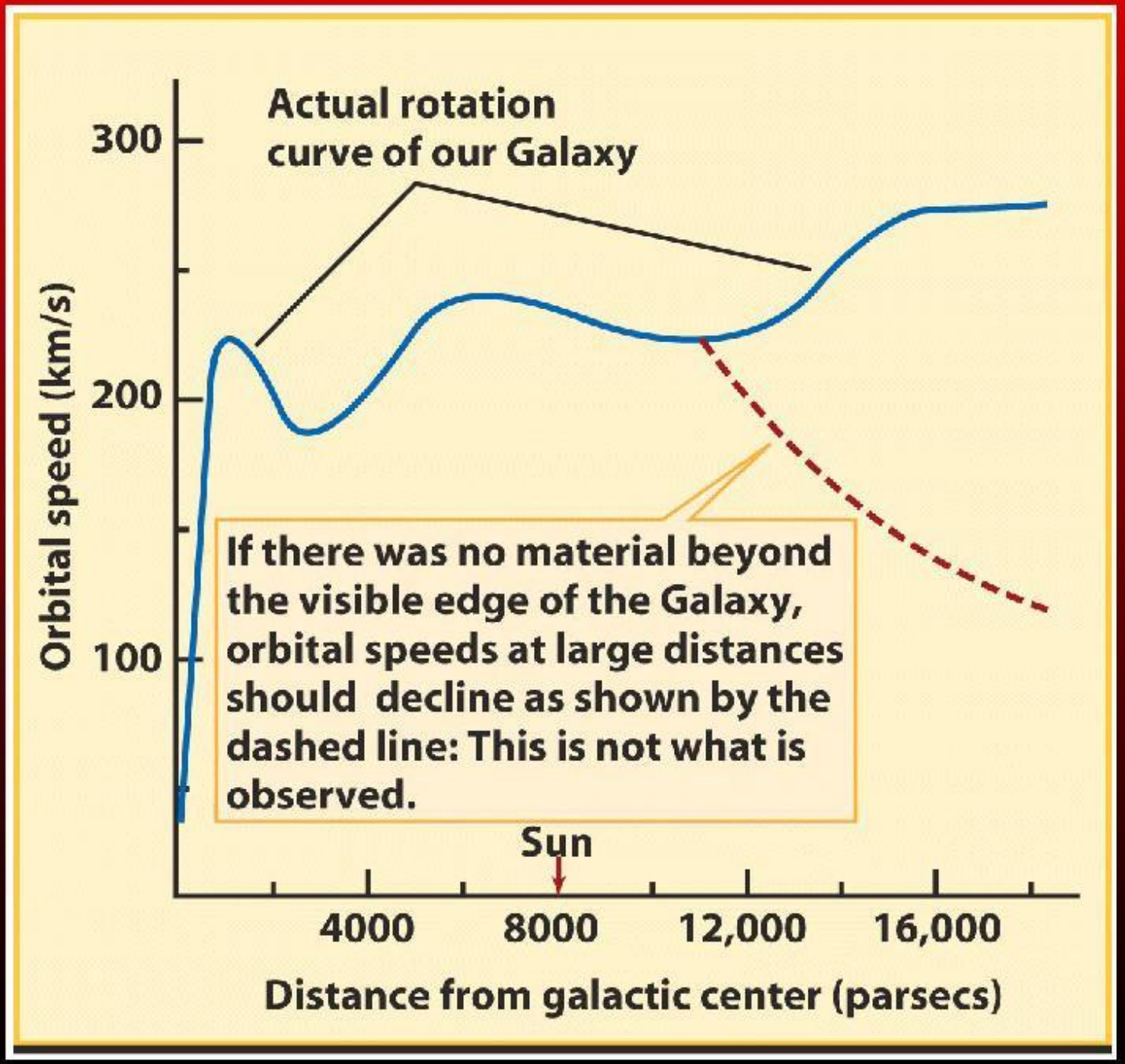
http://astro.uchicago.edu/classes/physci/120/spring-2007/

Galaxy is not Dominated by Central Mass

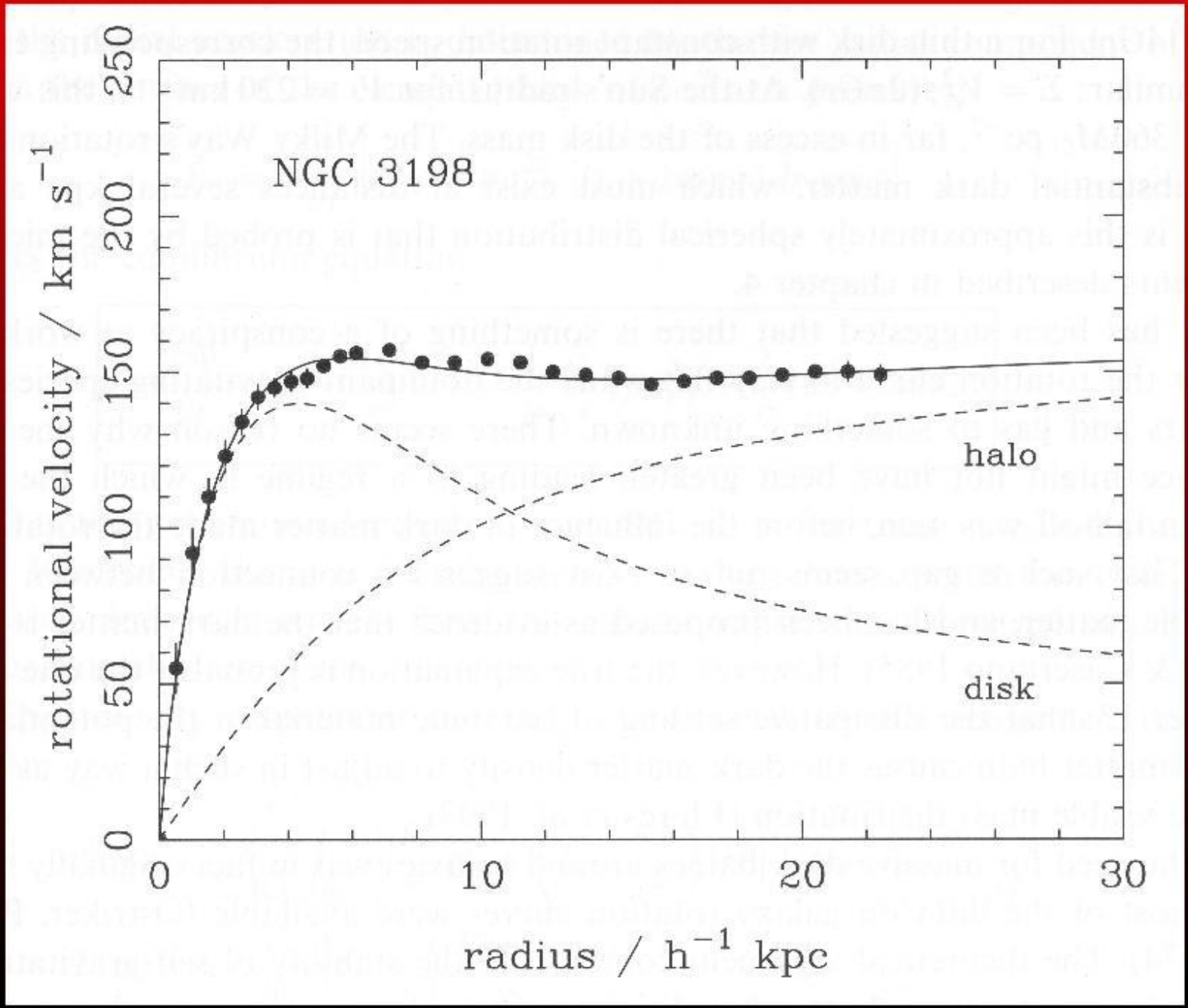


Left: drop in speed for dominant central mass
Right: observed constant speed at all distances

Our Galaxy's Rotation Curve



Rotation Curve and 2 Component Model

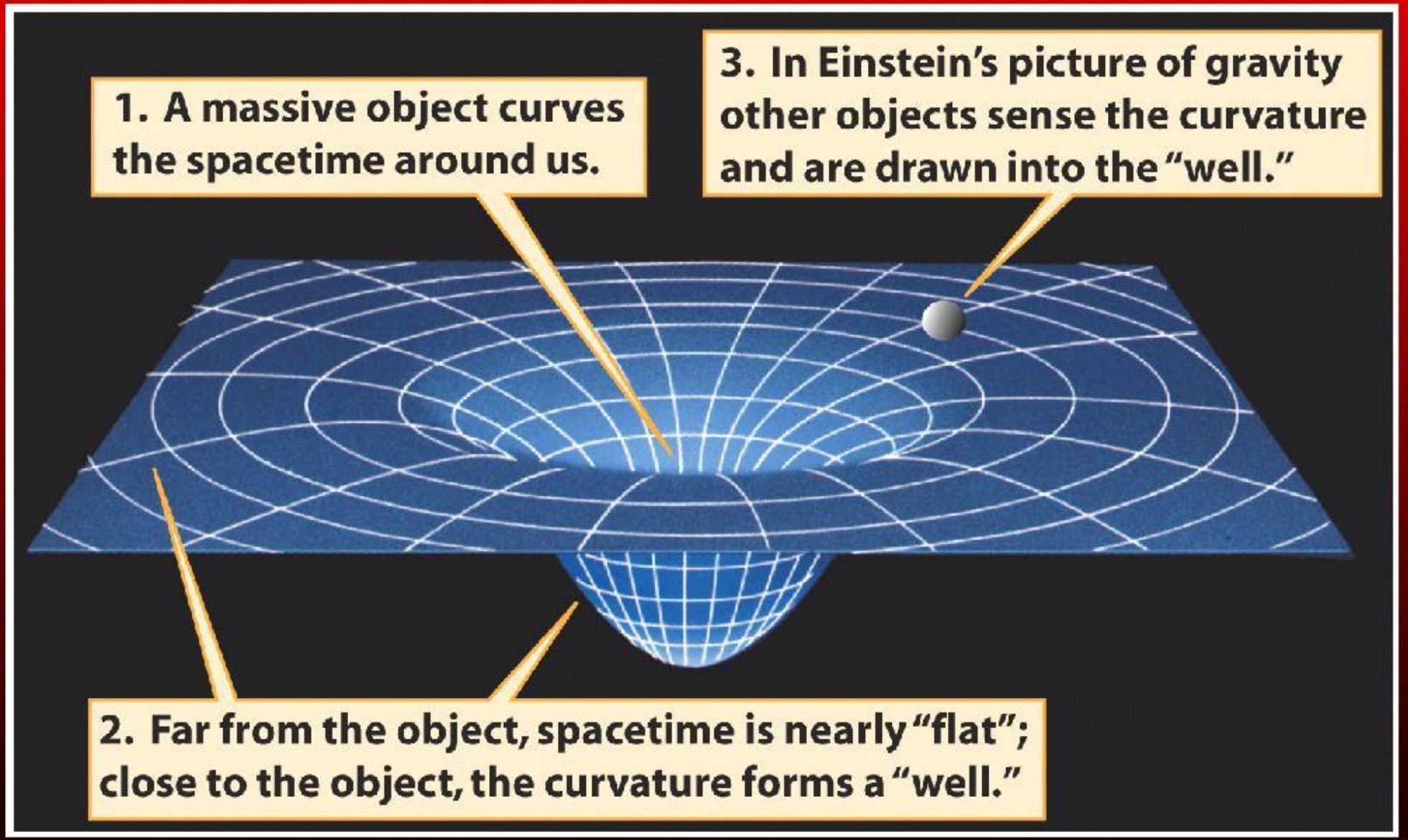


Dark Matter Halo

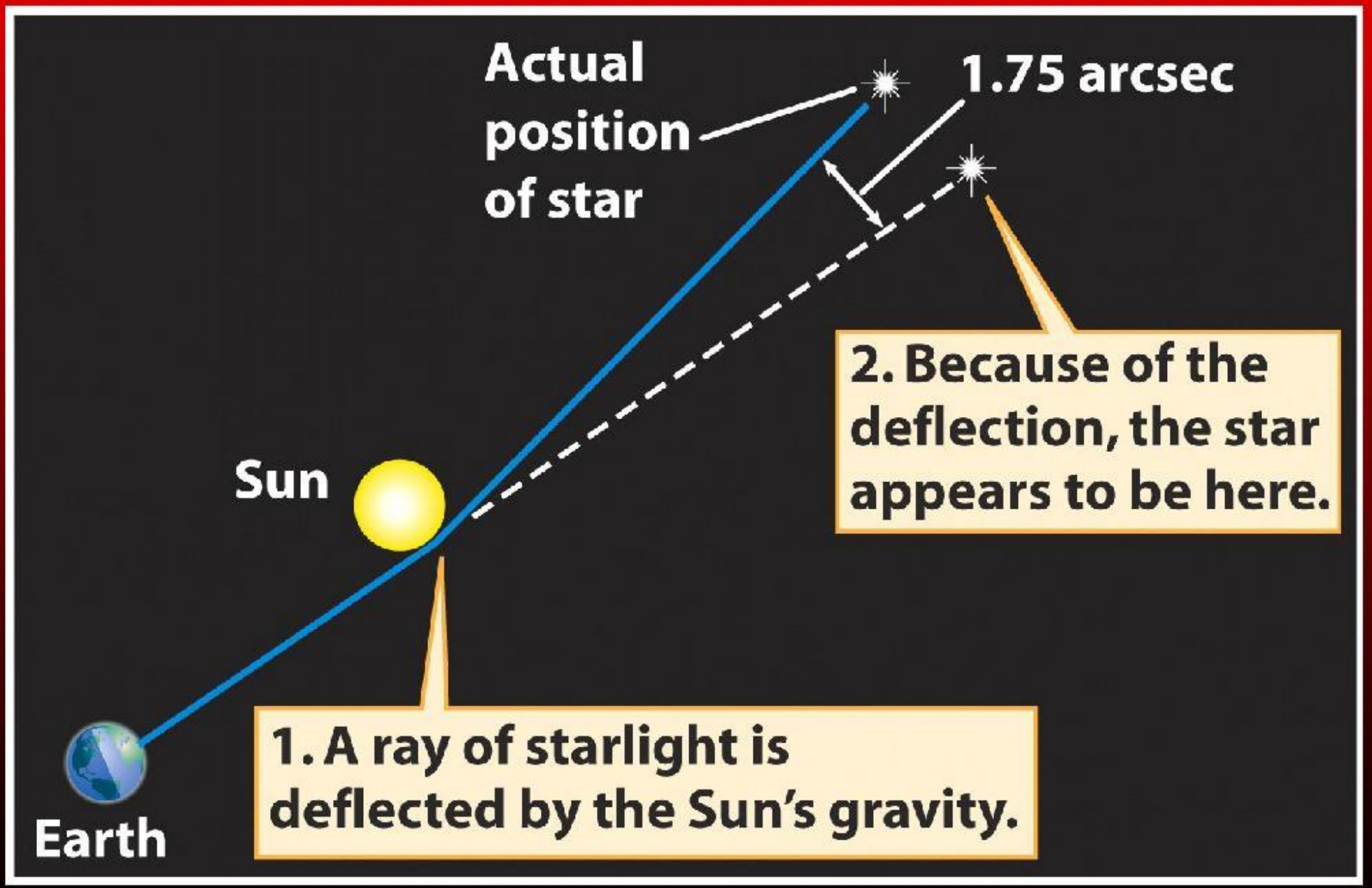
Two Proposed Explanations of the Dark Matter Problem:

- The dark matter is just planet sized lumps of ordinary matter which have so far escaped detection:
  - MACHO's
- The dark matter is some entirely different form of matter, which feels the gravitational force, but otherwise does not interact with ordinary material:
  - WIMP's

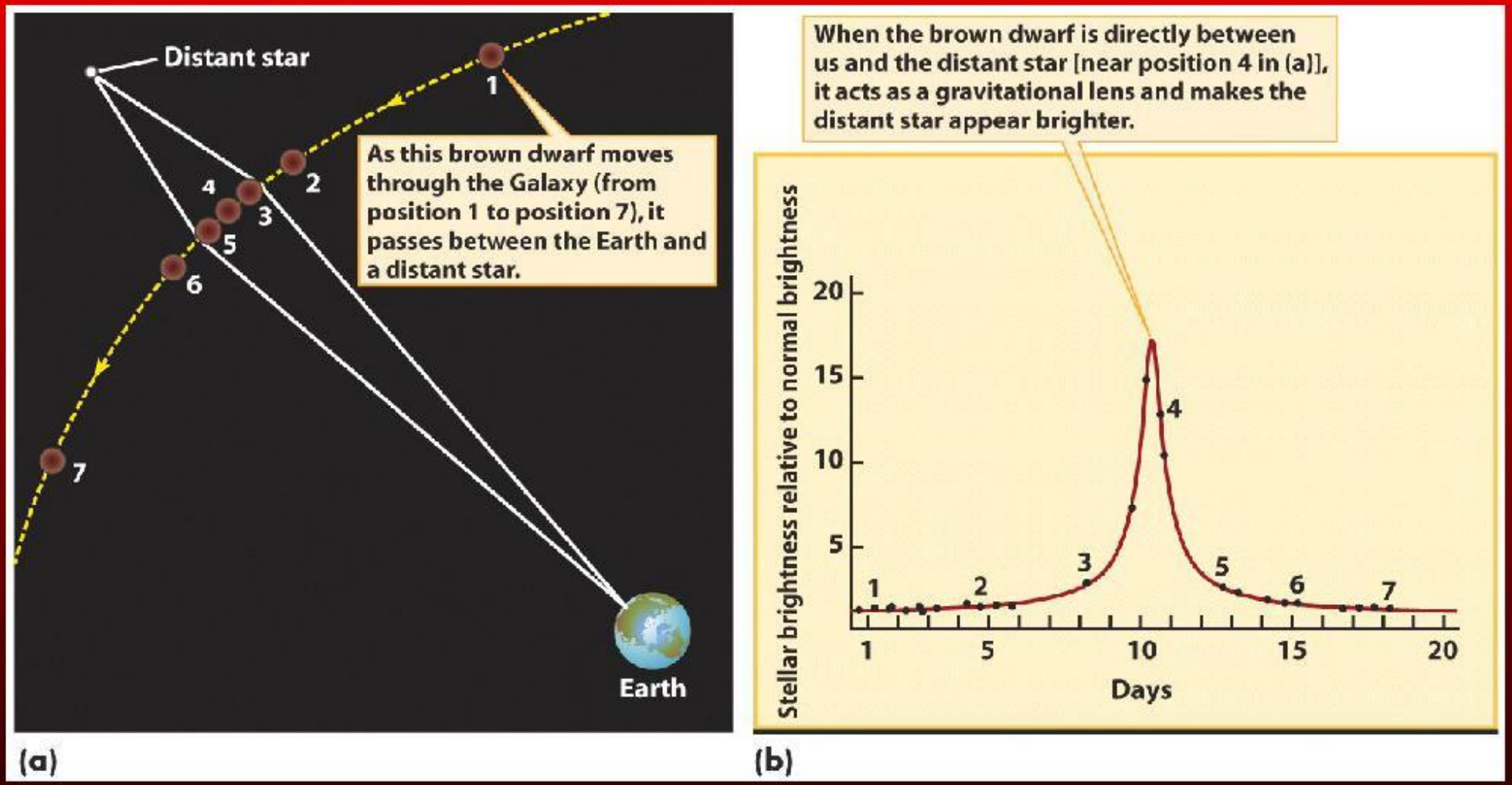
Curvature of Spacetime



Gravitational Deflection of Light

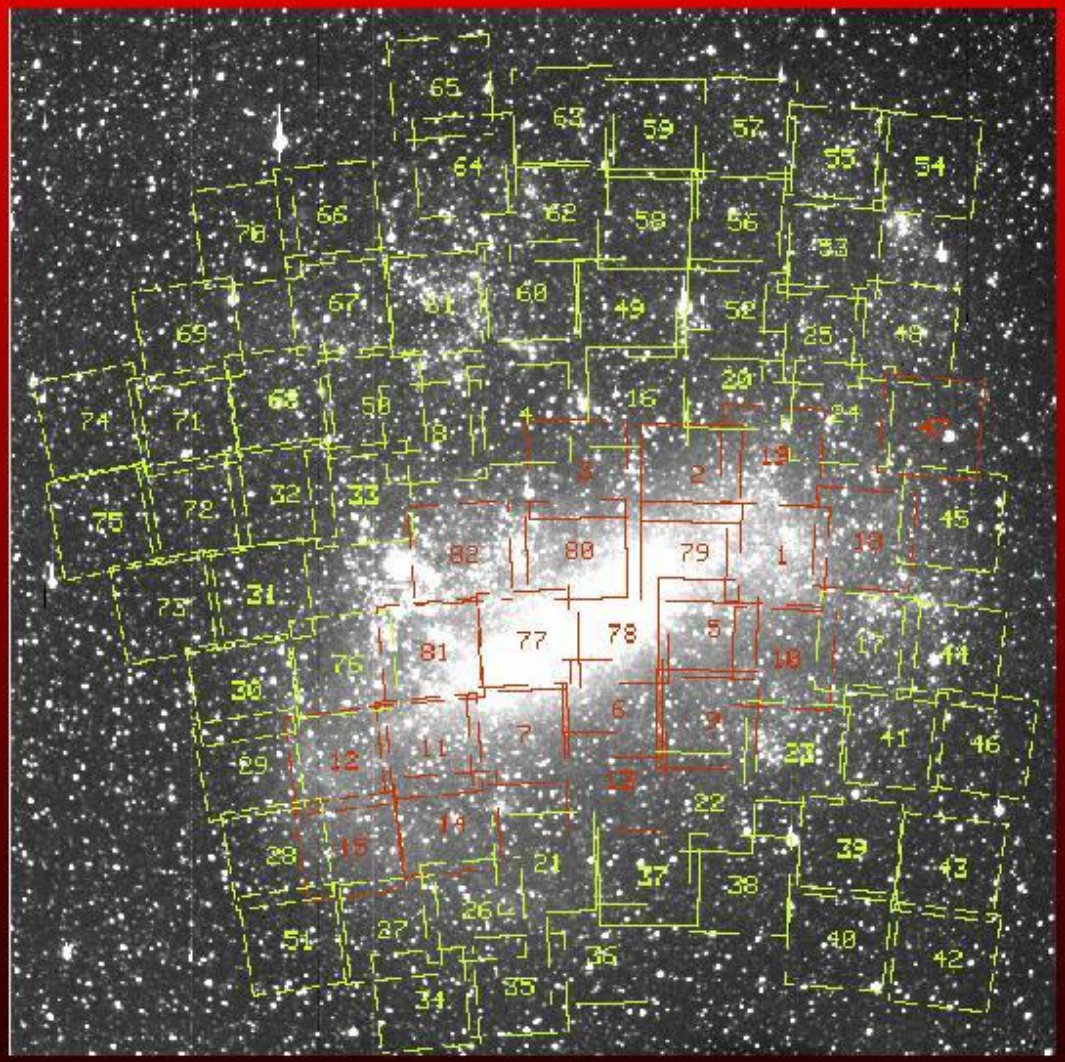


Massive Compact Halo Objects - MACHO's



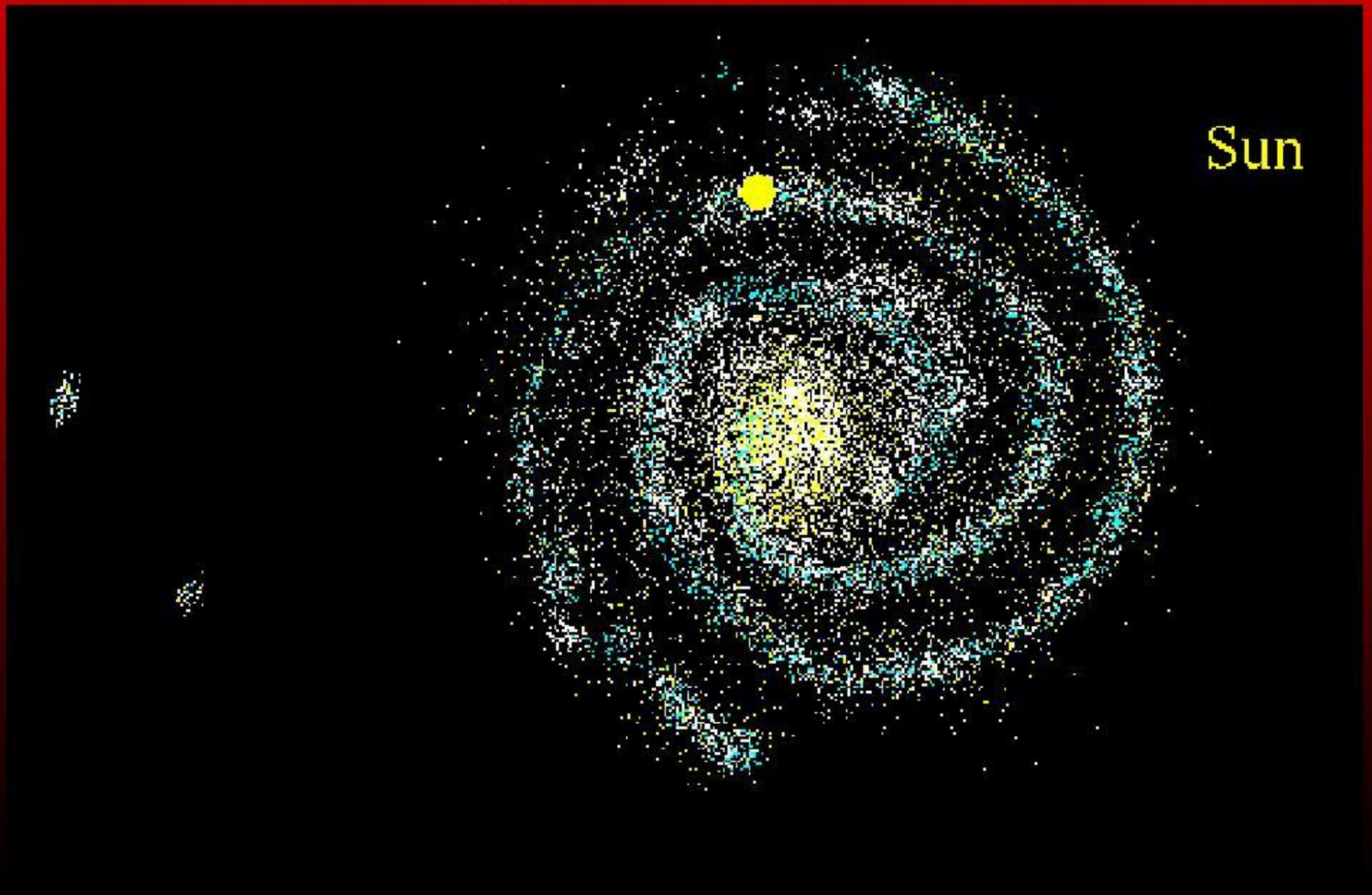
As MACHO passes infront of distant star it brightens for a short time

MACHO Collaboration

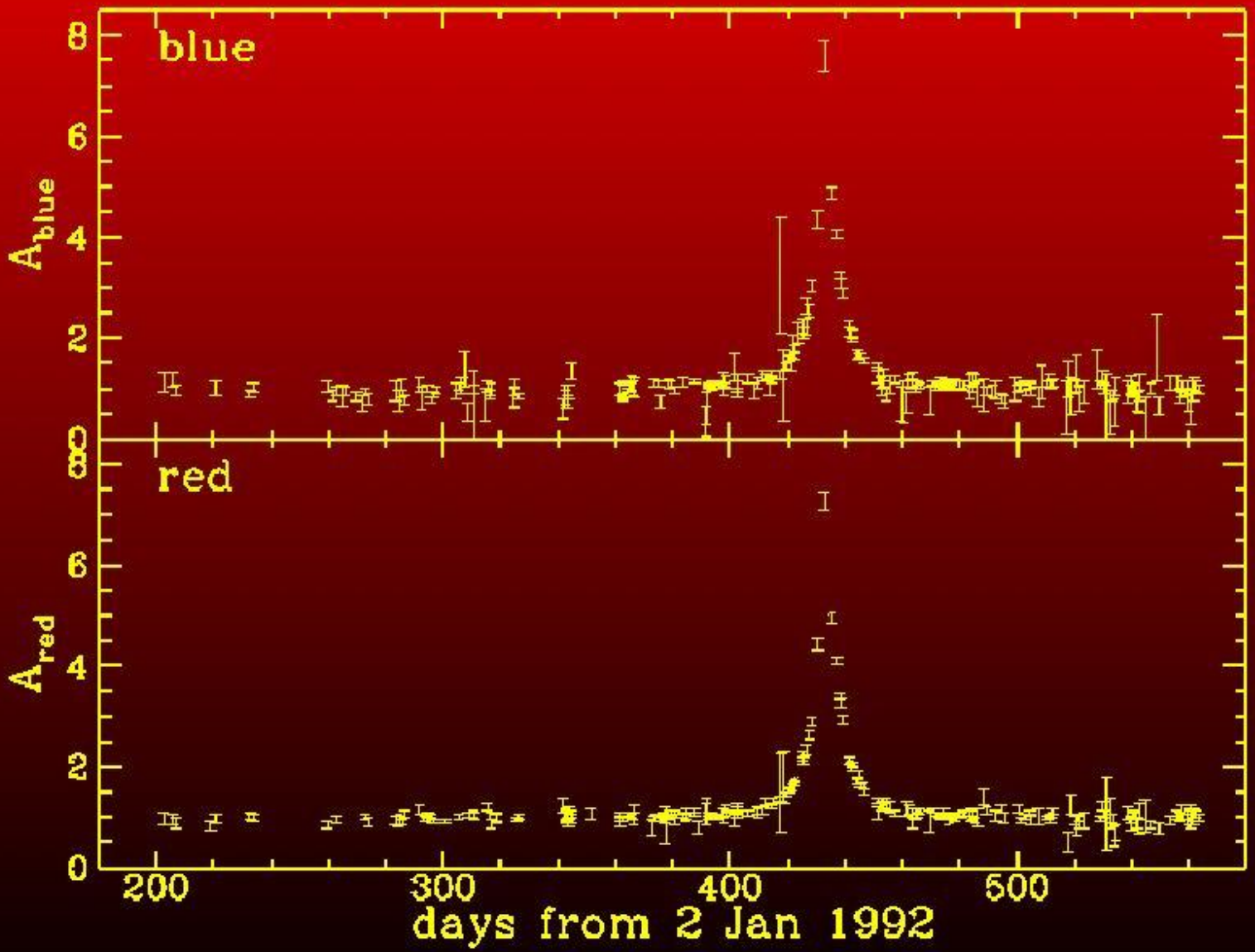


- Monitored 10 million stars in LMC & bulge for 8 years!
- Detected 20 "micro-lensing" events.
- Not enough to explain the dark matter...

The Magellanic Clouds - Our Nearest Neighbor Galaxies



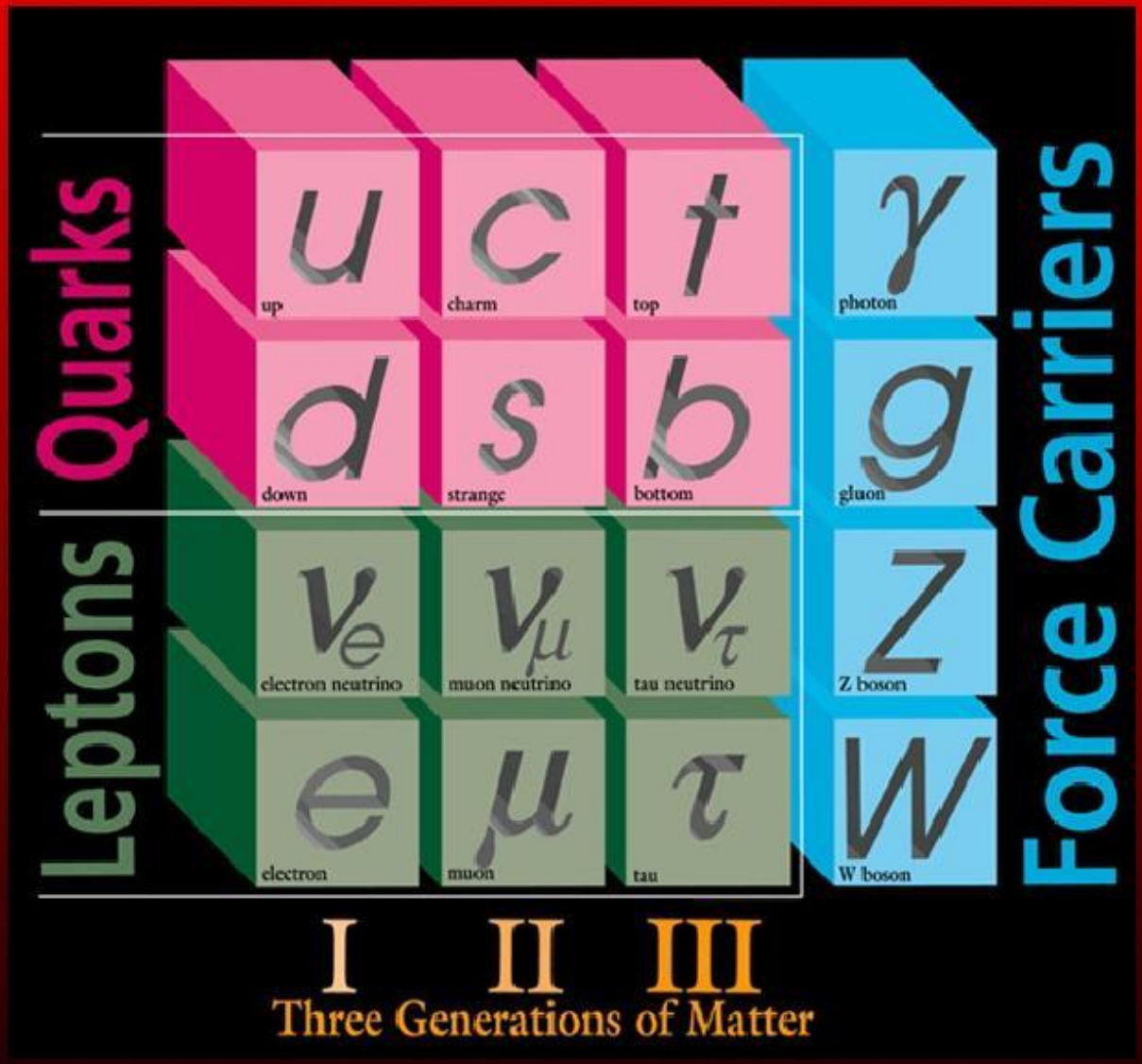
Real MACHO Event towards LMC



Weakly Interacting Massive Particles - WIMP's

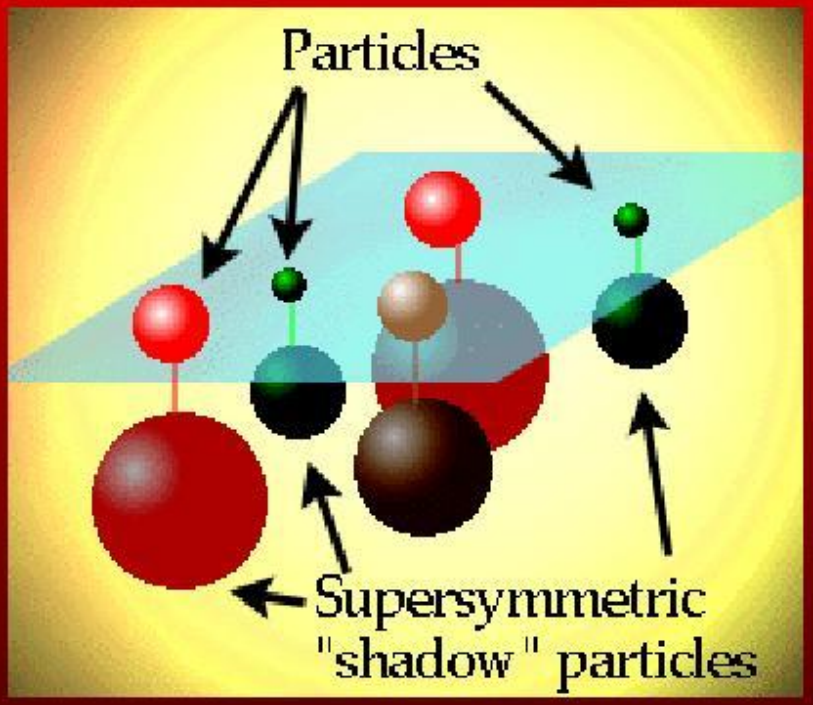
- The Standard Model of Particle Physics is very advanced and successful.
- But it is clearly an incomplete theory...

Standard Model



But are there other particles?

Super-Symmetry



- Predicts that every particle has a "super" partner shadow particle.
- (Some of) these may be stable and if so could be the dark matter.

WIMP Detectors

- Look for the vast numbers of WIMP's which may be streaming though the Earth all the time.
- But probability to interact is very low - potential signal is tiny!
- Therefore need to suppress fake signal as much as possible:
  - Ultra-pure detector materials.
  - Deep underground laboratories.

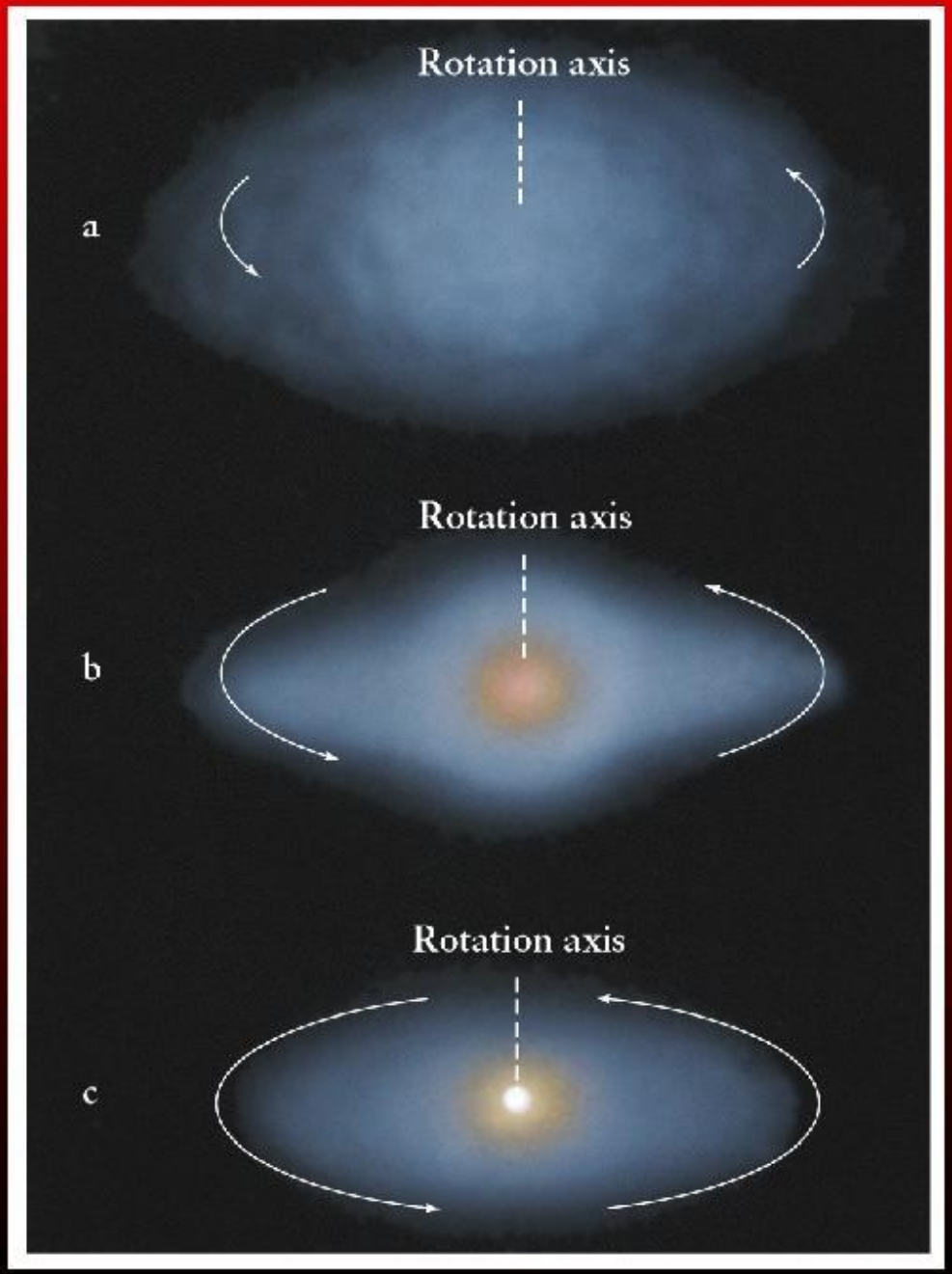
CDMS Detector

Not so Pretty on the Surface...

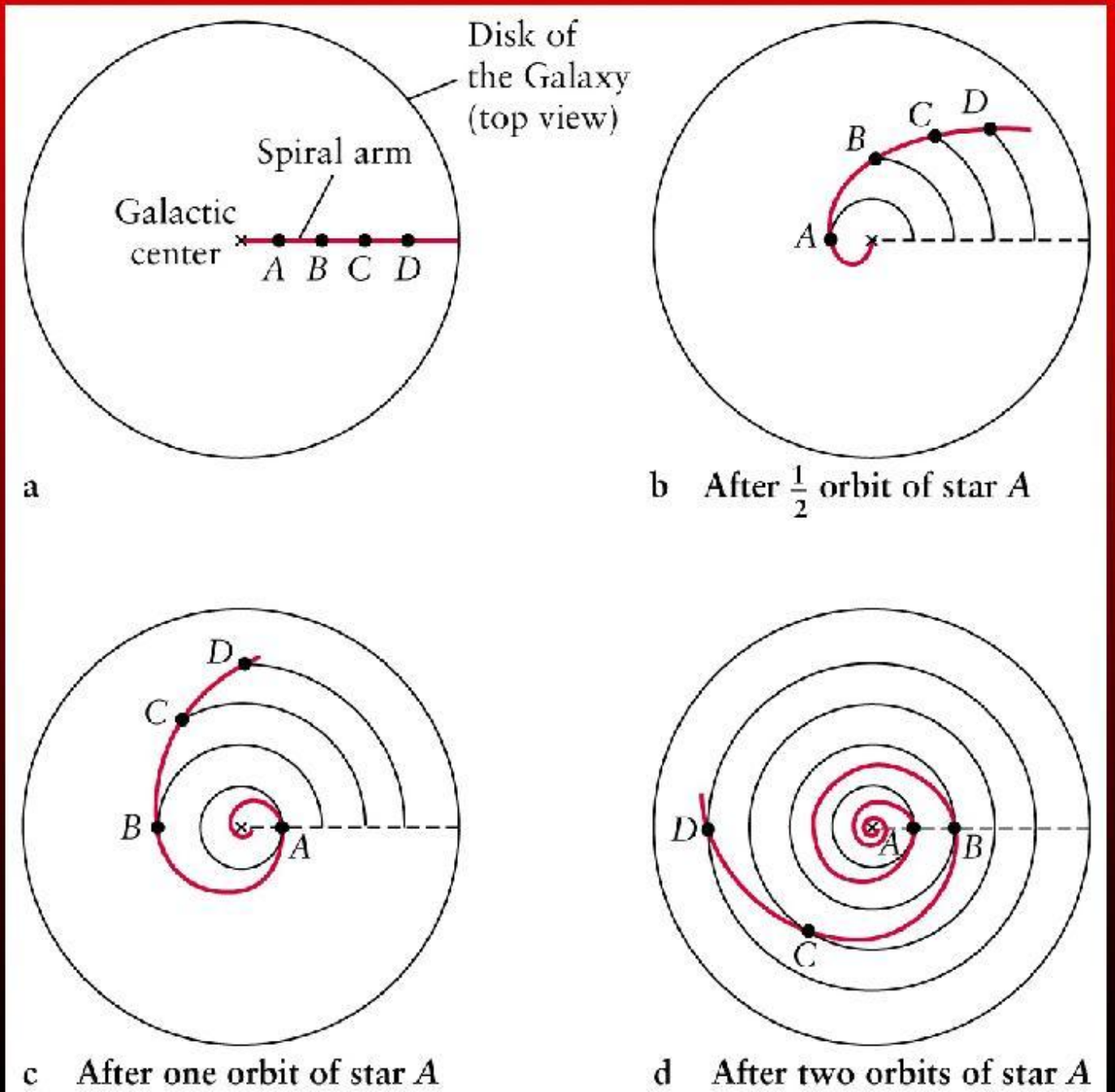
MACHO Collaboration?

WIMP Collaboration?

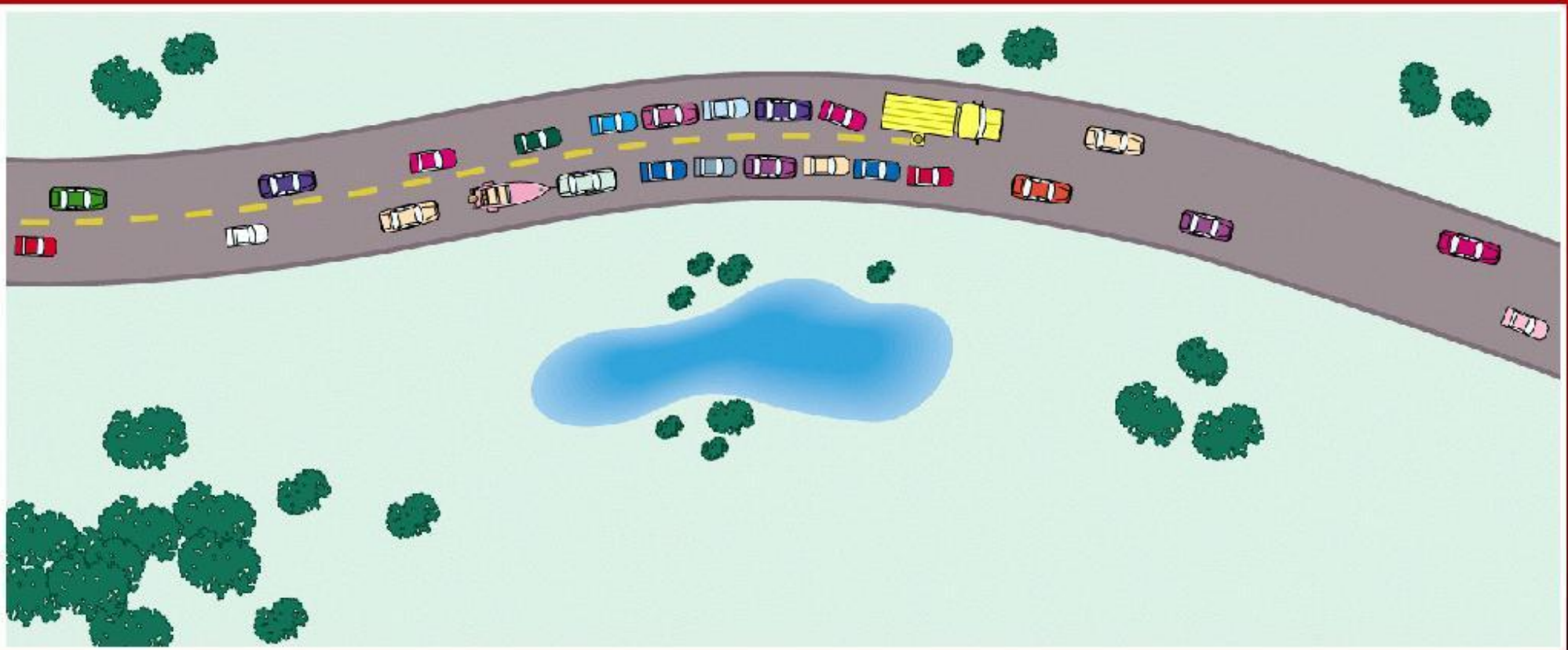
Formation of Disk



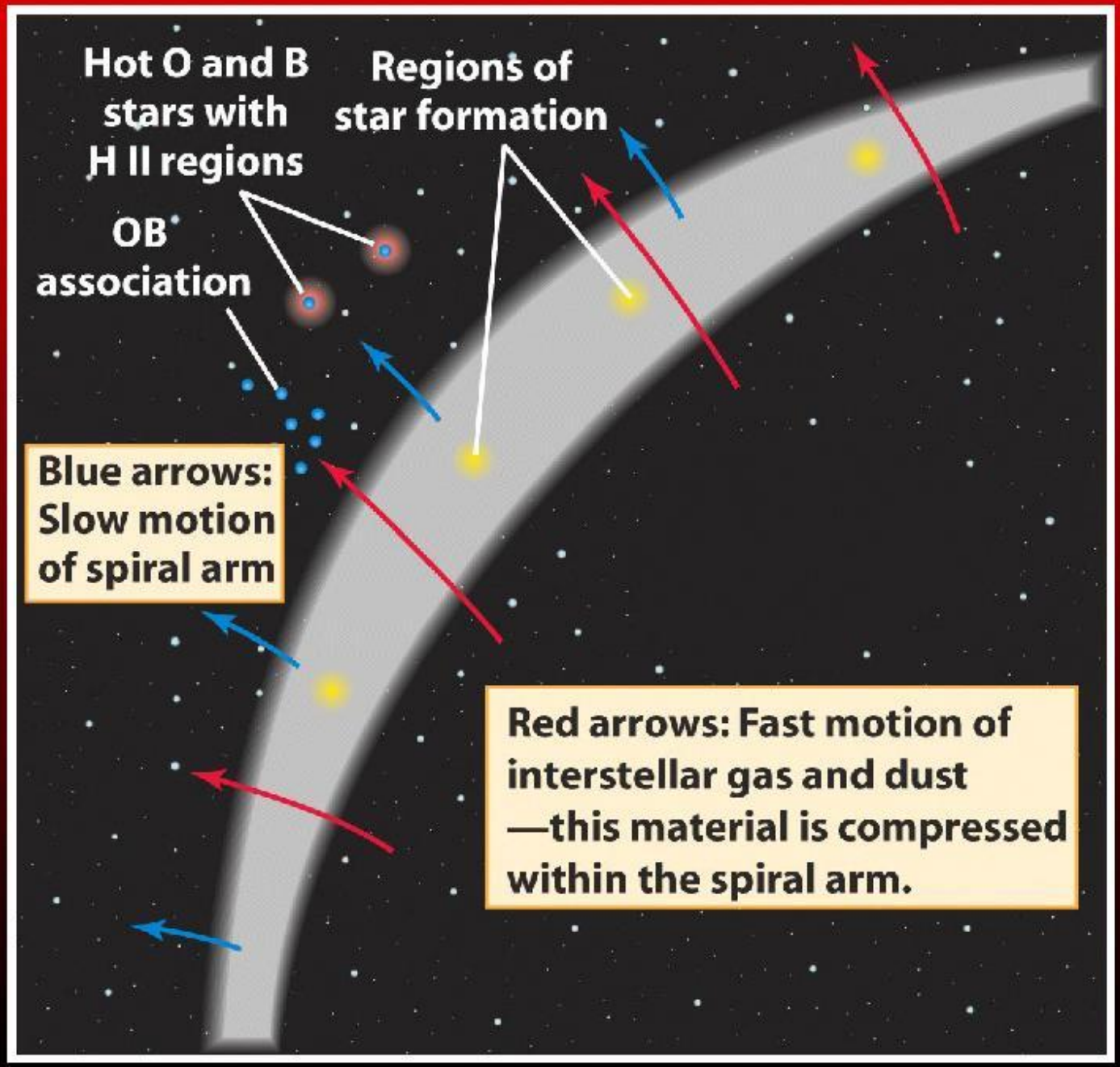
Winding Dilemma



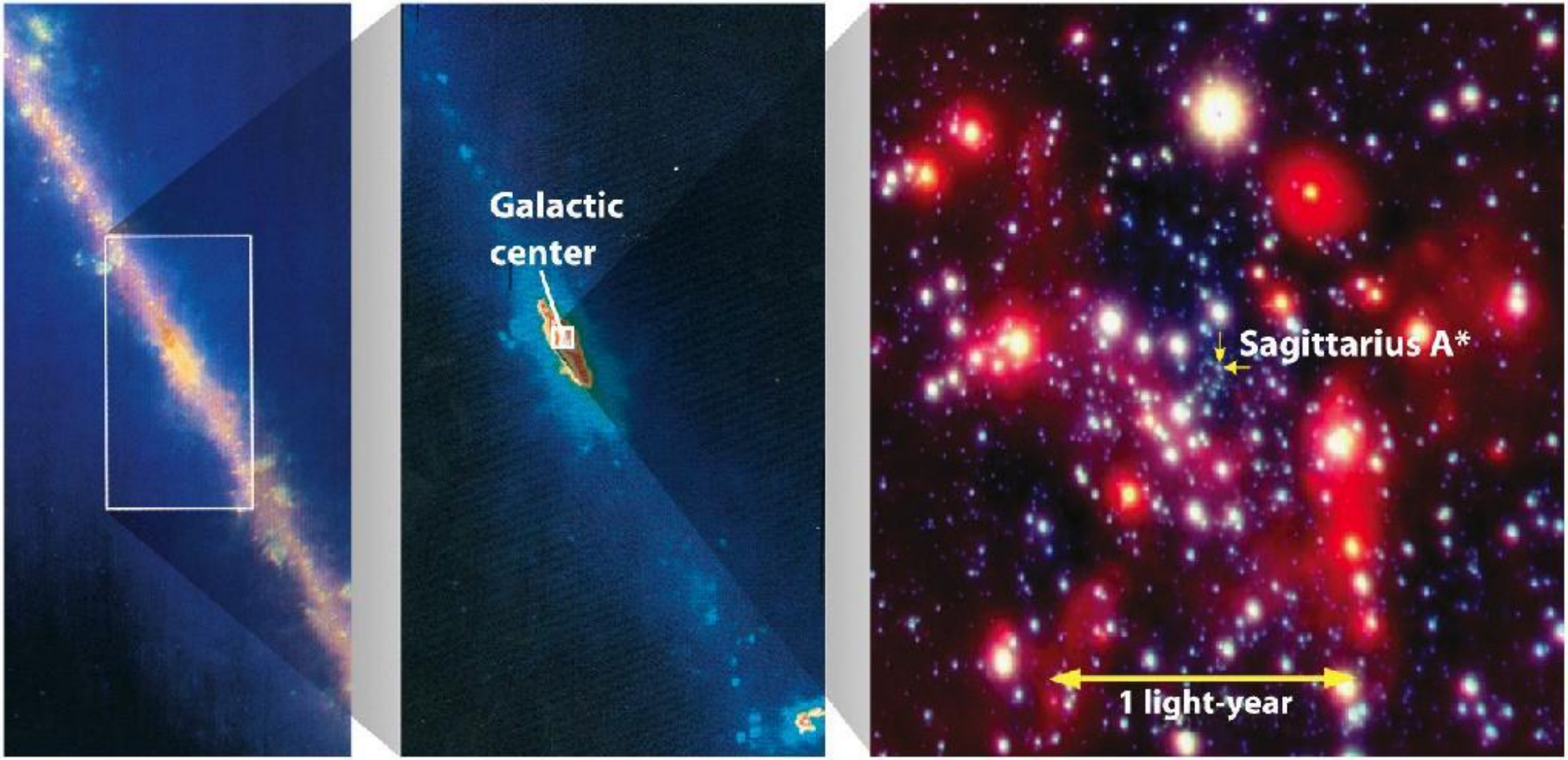
Road Painter Analogy



Star Formation Triggered by Spiral Arm



Infrared View of Galactic Center

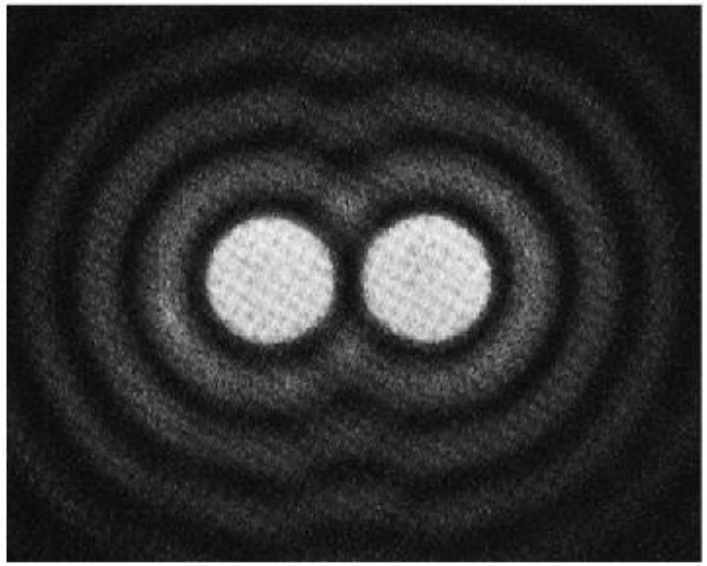


(a) A wide-angle (50°) infrared view

(b) A close-up view shows a more luminous region at the galactic center

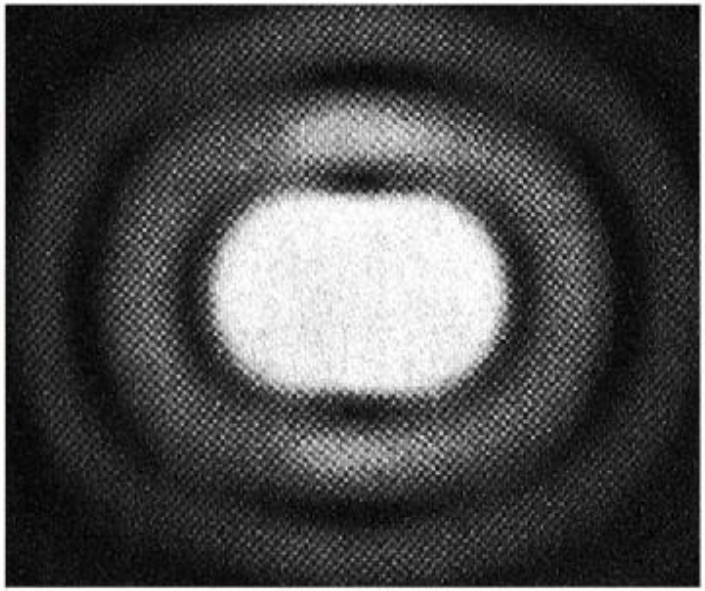
(c) An extreme close-up view centered on Sagittarius A*, a radio source at the very center of the Milky Way Galaxy, shows hundreds of stars within 1 ly (0.3 pc)

Diffraction Limit



(a)

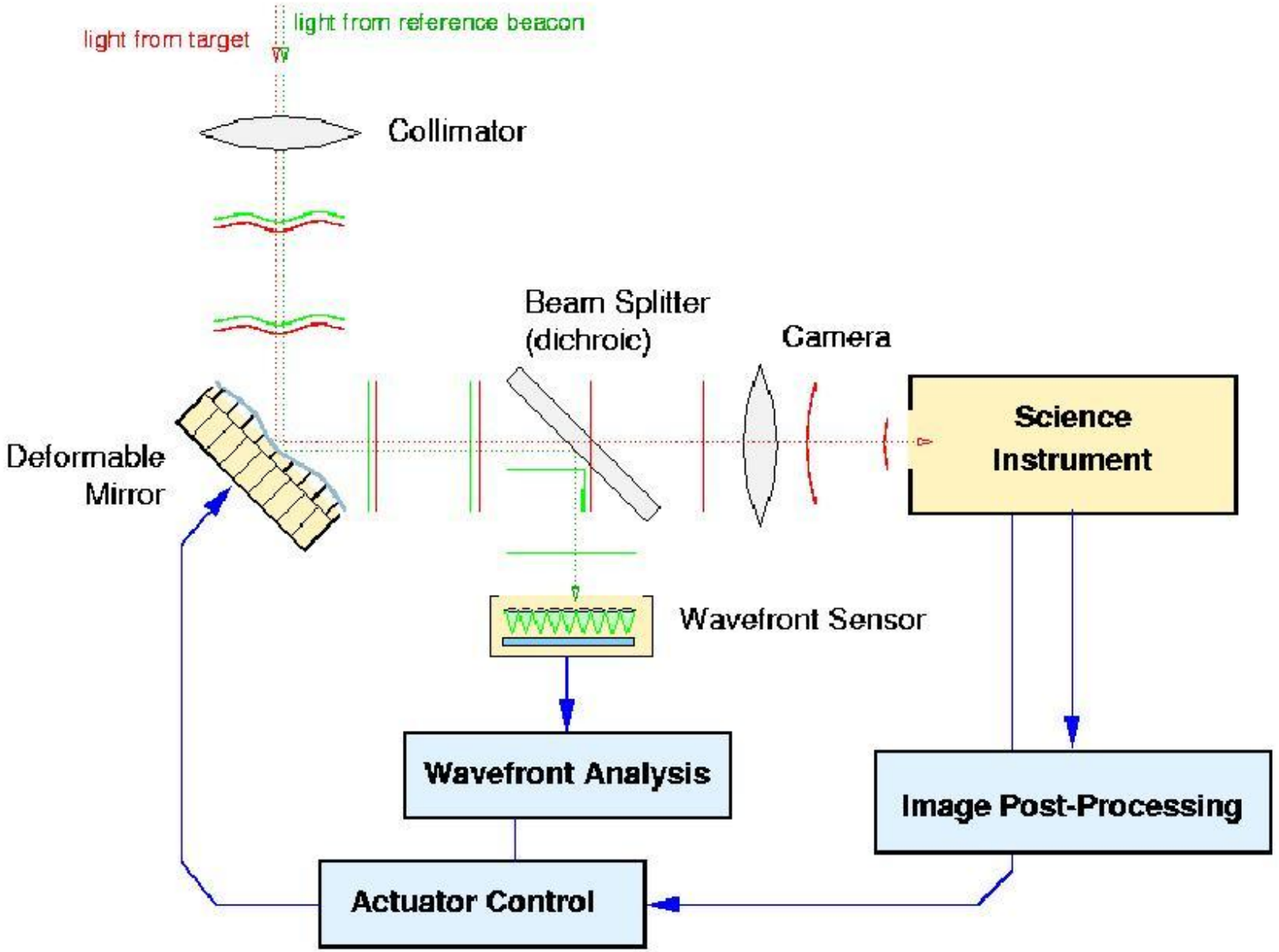
Two light sources with angular separation greater than angular resolution of telescope: Two sources easily distinguished



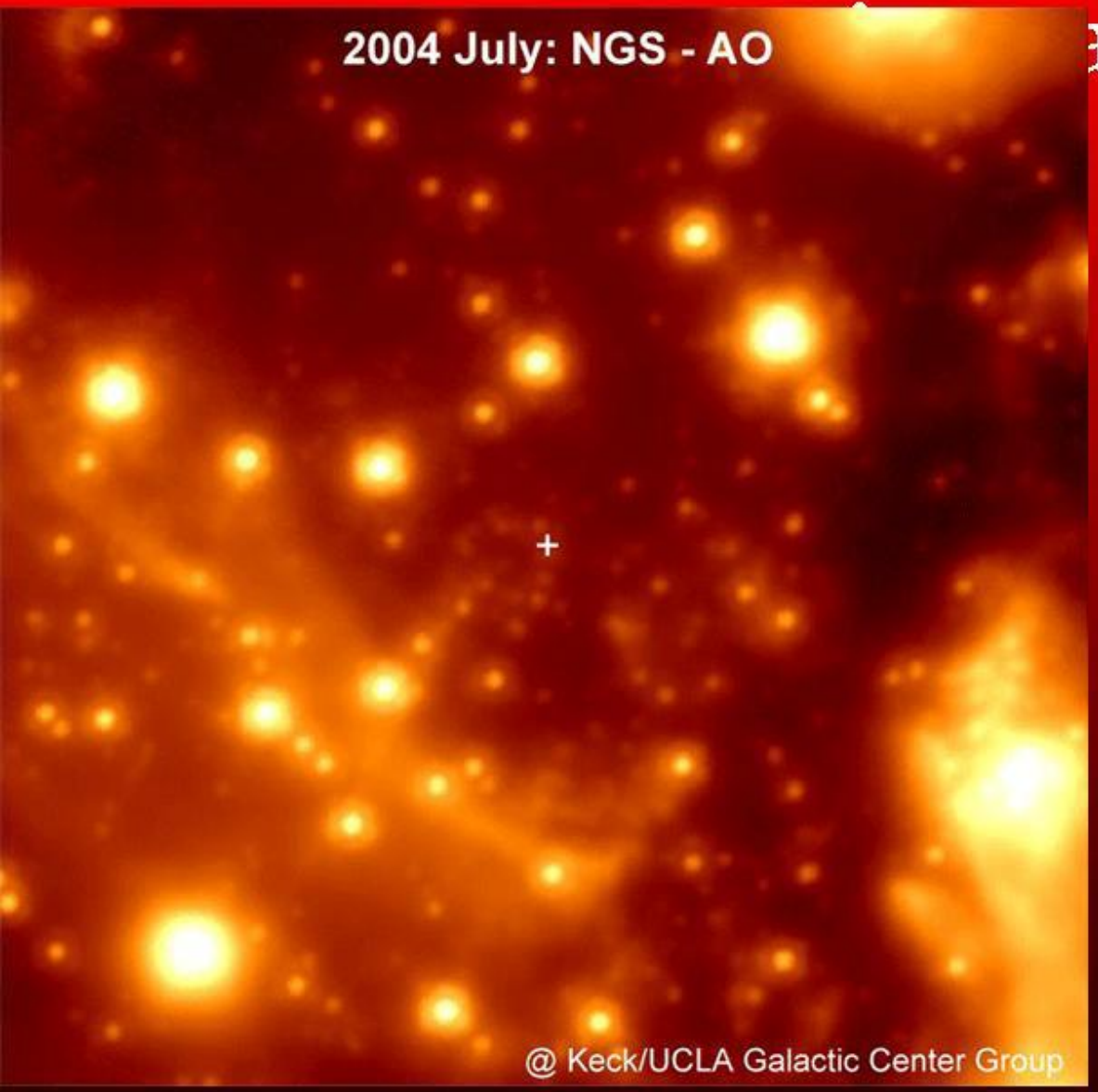
(b)

Light sources moved closer so that angular separation equals angular resolution of telescope: Just barely possible to tell that there are two sources

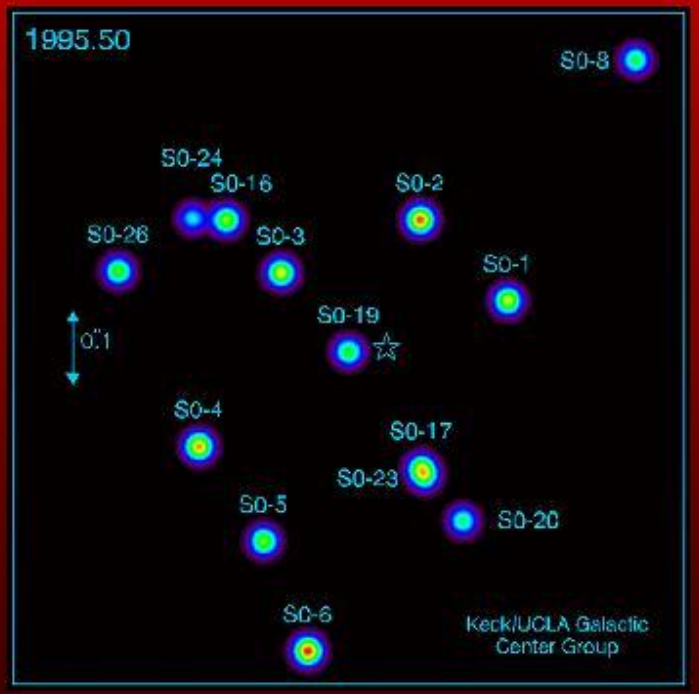
Adaptive Optics



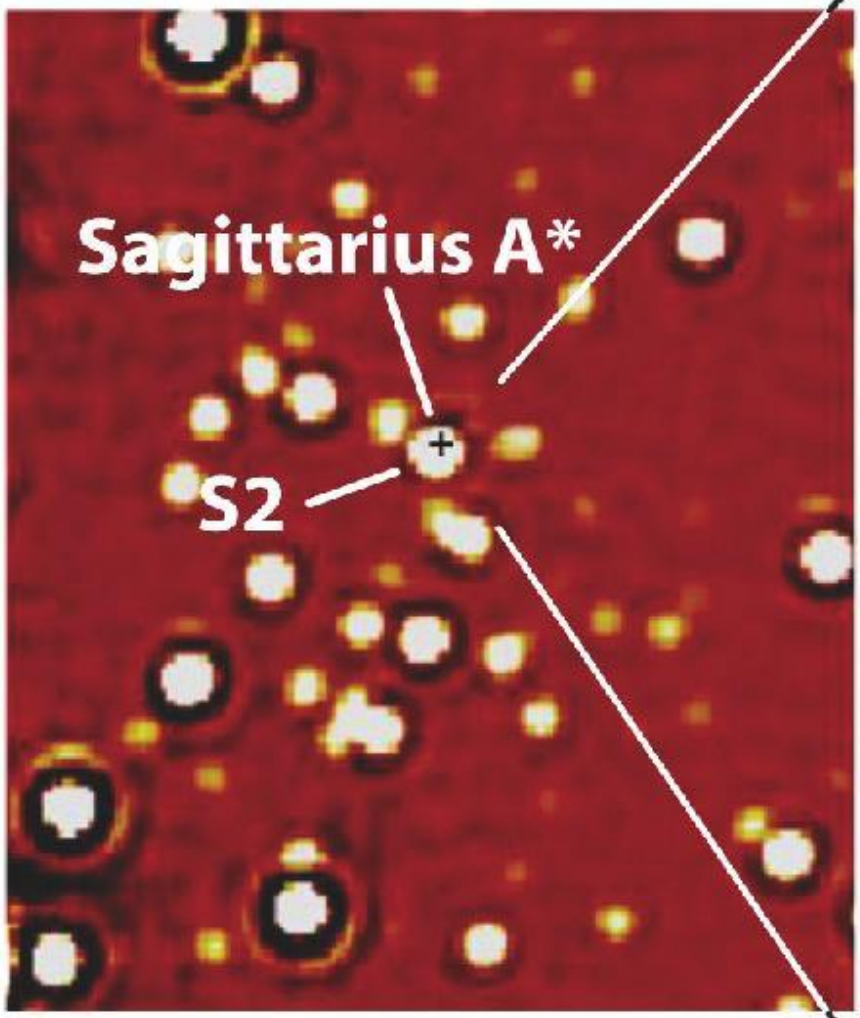
aser Guide Star

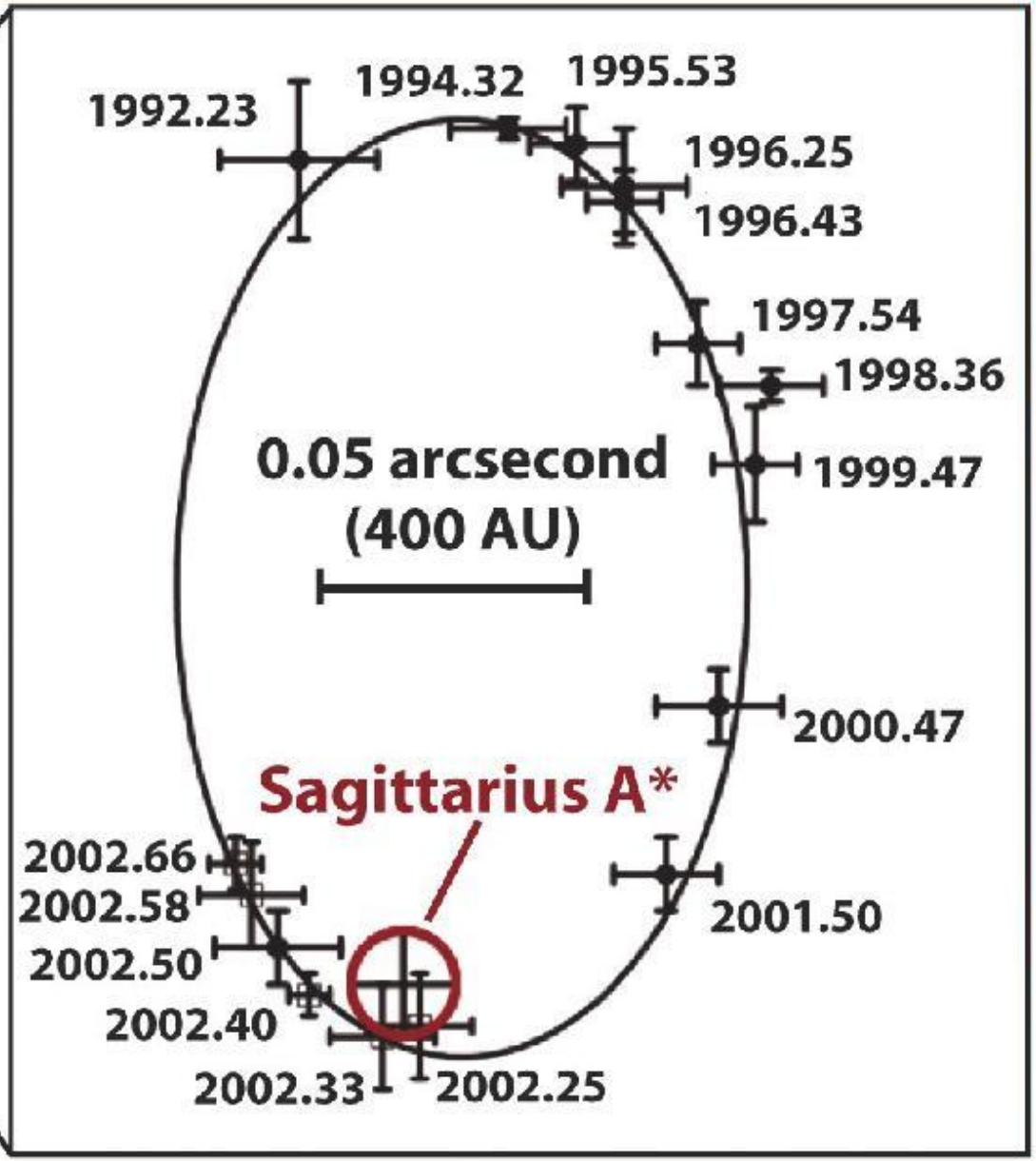


Galactic Center Motions



Star Passing Close to Galactic Center





X-Ray View of Galactic Center