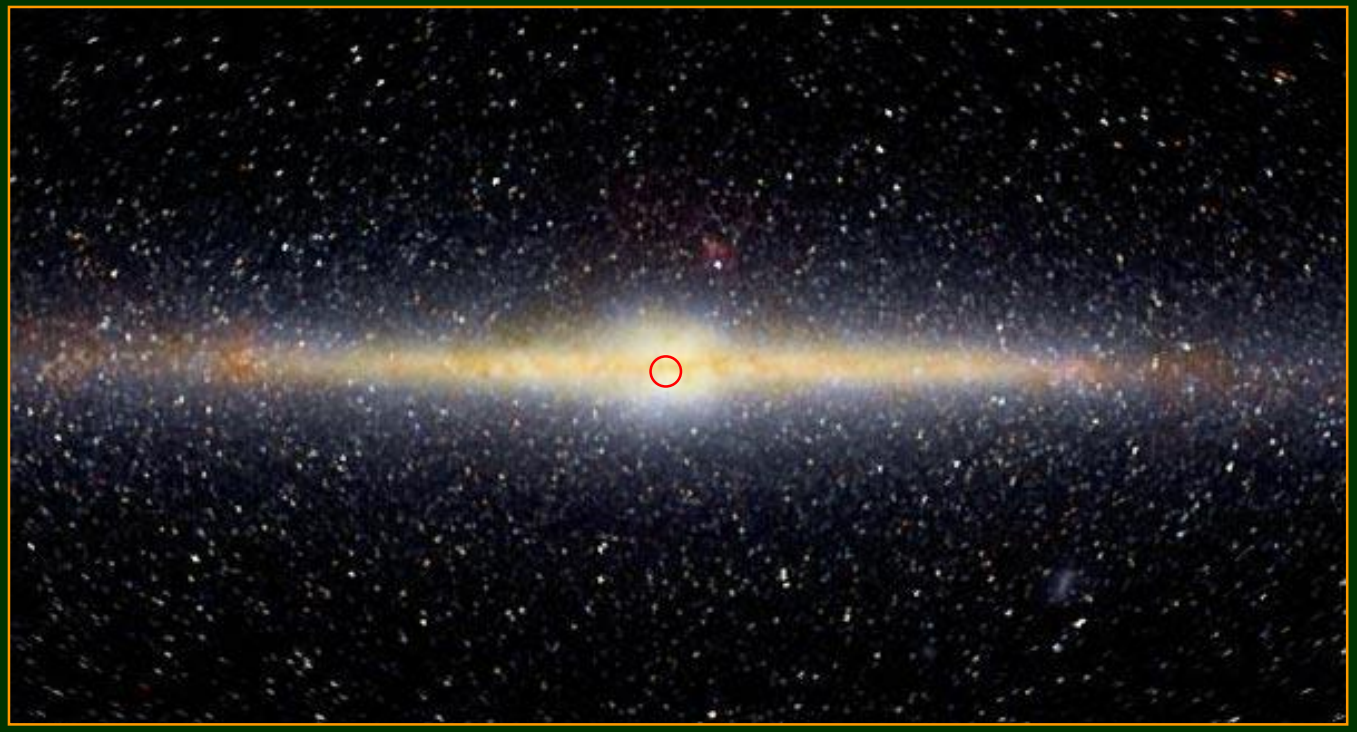
SISTEMAS ESTELARES

Material didáctico para las clases de
"*El centro de la Vía Láctea*"

Clases teóricas dictadas por:
Dra. Lilia P. Bassino

El *centro* de la Vía Láctea (imagen IR)



E. L. Wright (UCLA), The COBE Project, DIRBE, NASA

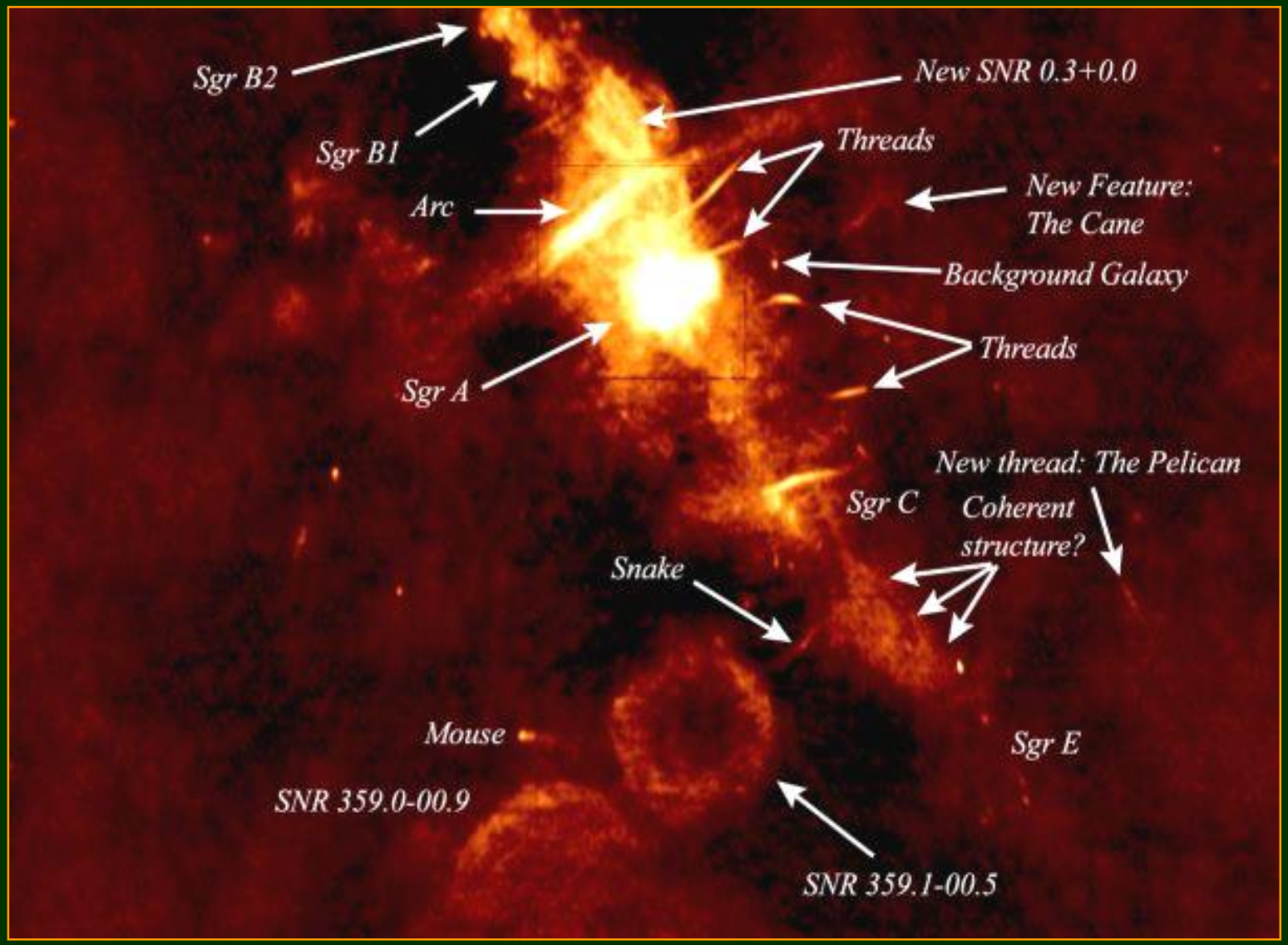
Centro Galáctico: imagen Chandra en rayos X (estrellas y gas)

120 pc

280 pc

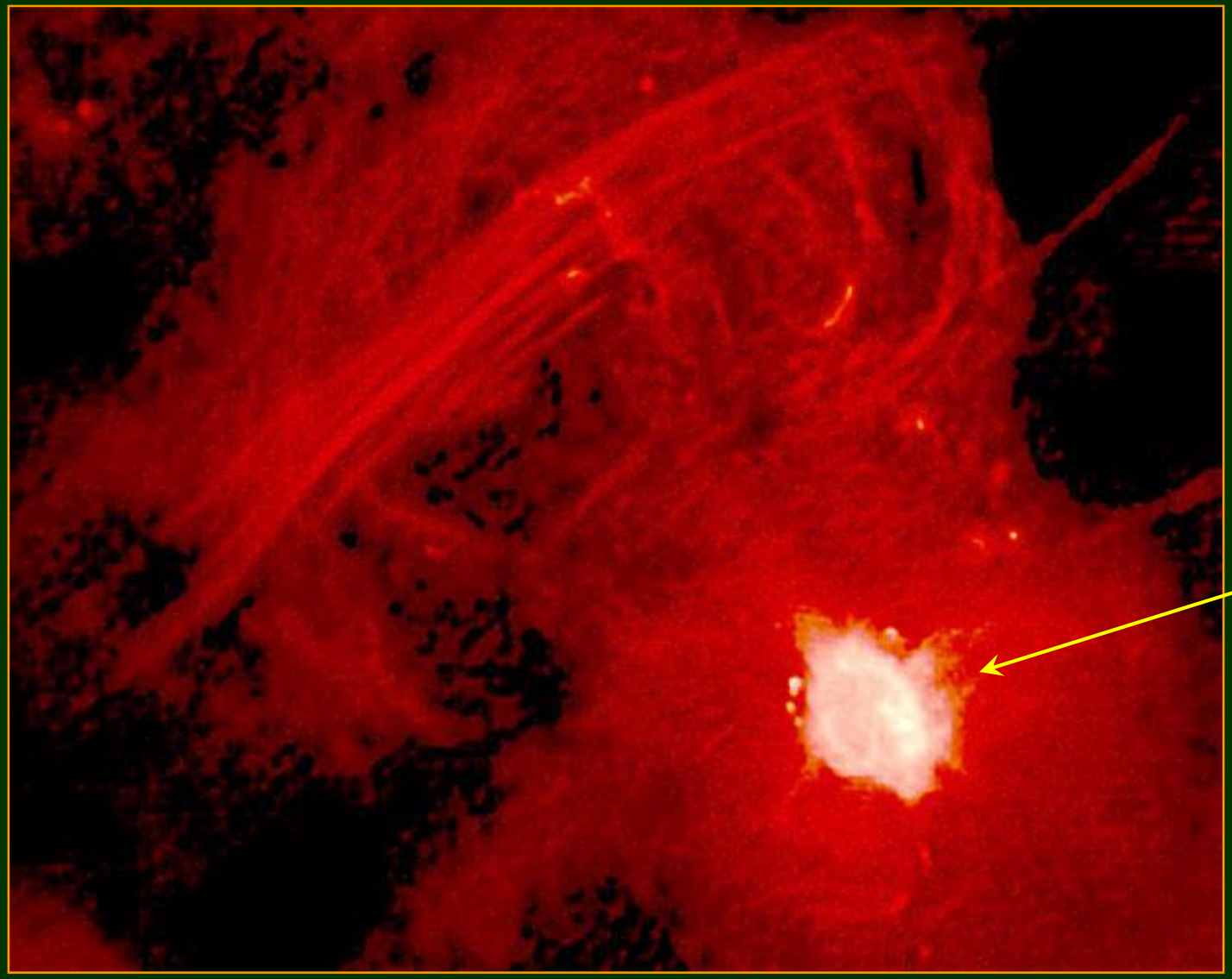
D. Wang (UMass) et al., CXC, NASA

Centro Galáctico: imagen en ondas de radio (VLA)



N. E. Kassim, D. S. Briggs, T. J. W. Lazio, T. N. LaRosa, J. Imamura (NRL/RSD)

El “Arco” del Centro Galáctico, en radio



Farhad Zadeh et al. (Northwestern), VLA, NRAO

El “Arco” y el cúmulo Arches del Centro Galáctico

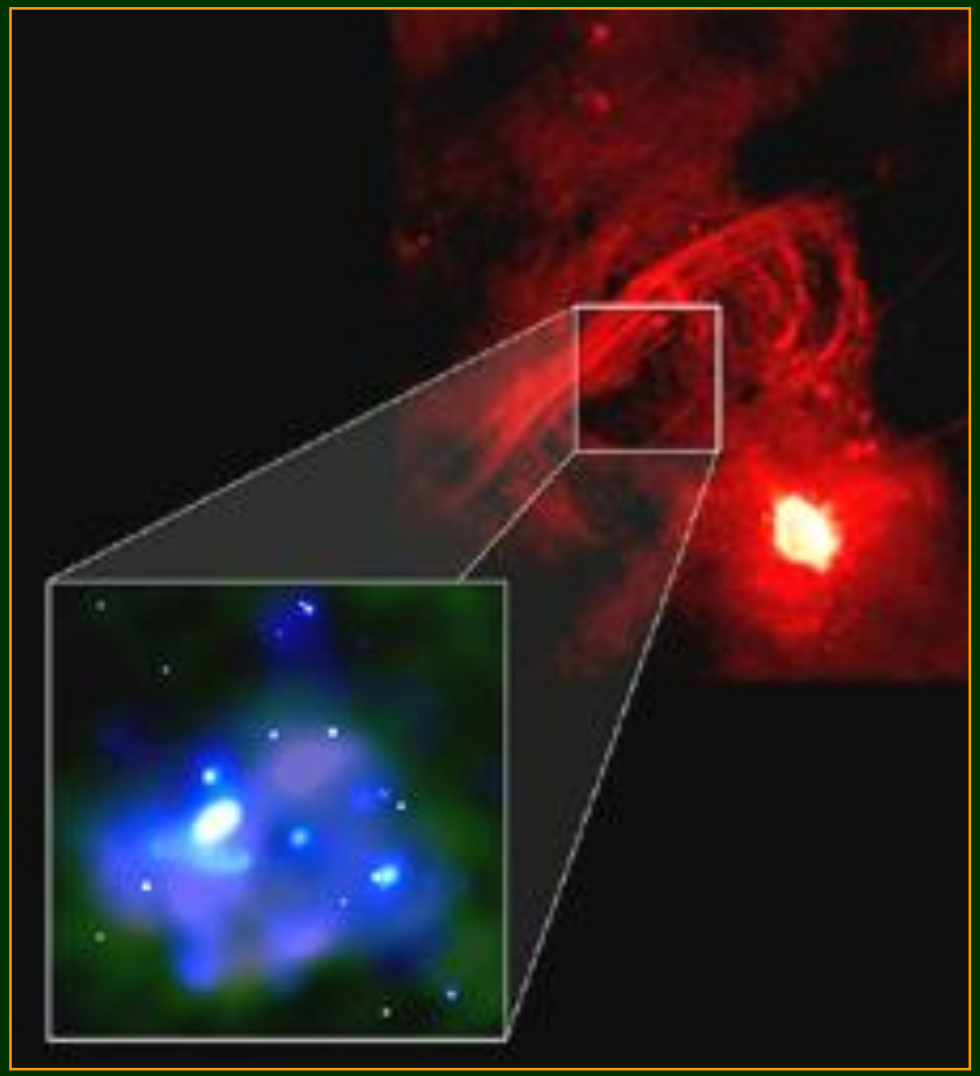


Imagen combinada:

rojo → radio

blanco → infrarrojo

azul → rayos X

El cúmulo Arches contiene más de 100 estrellas jóvenes y masivas.

X-ray; NASA/CXC/Northwestern/F. Zadeh et al., IR; NASA/HST/NICMOS, Radio;NRAO/VLA/C. Lang

Detalle del centro galáctico: imagen infrarroja VLT

Rainer Schödel (MPE) et al., NAOS-CONICA, ESO

Determinación de la distancia Sol - Centro Galáctico

Examples of proper motions of H_2O maser spots in Sgr B2(N)

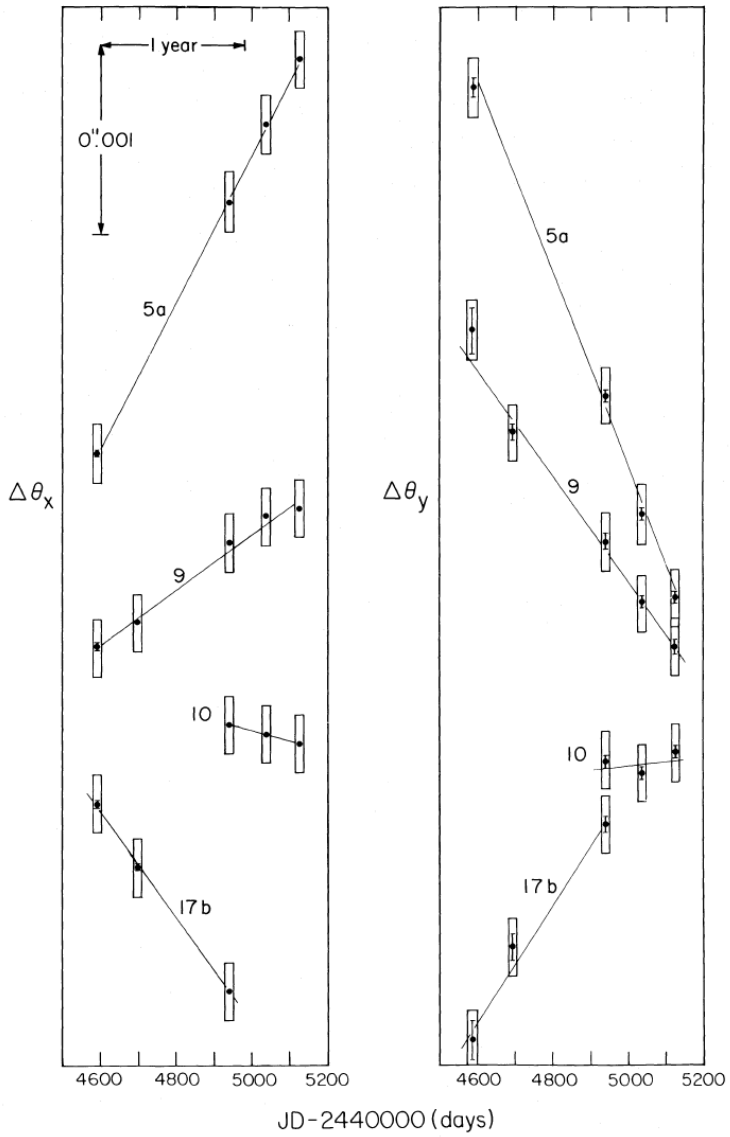
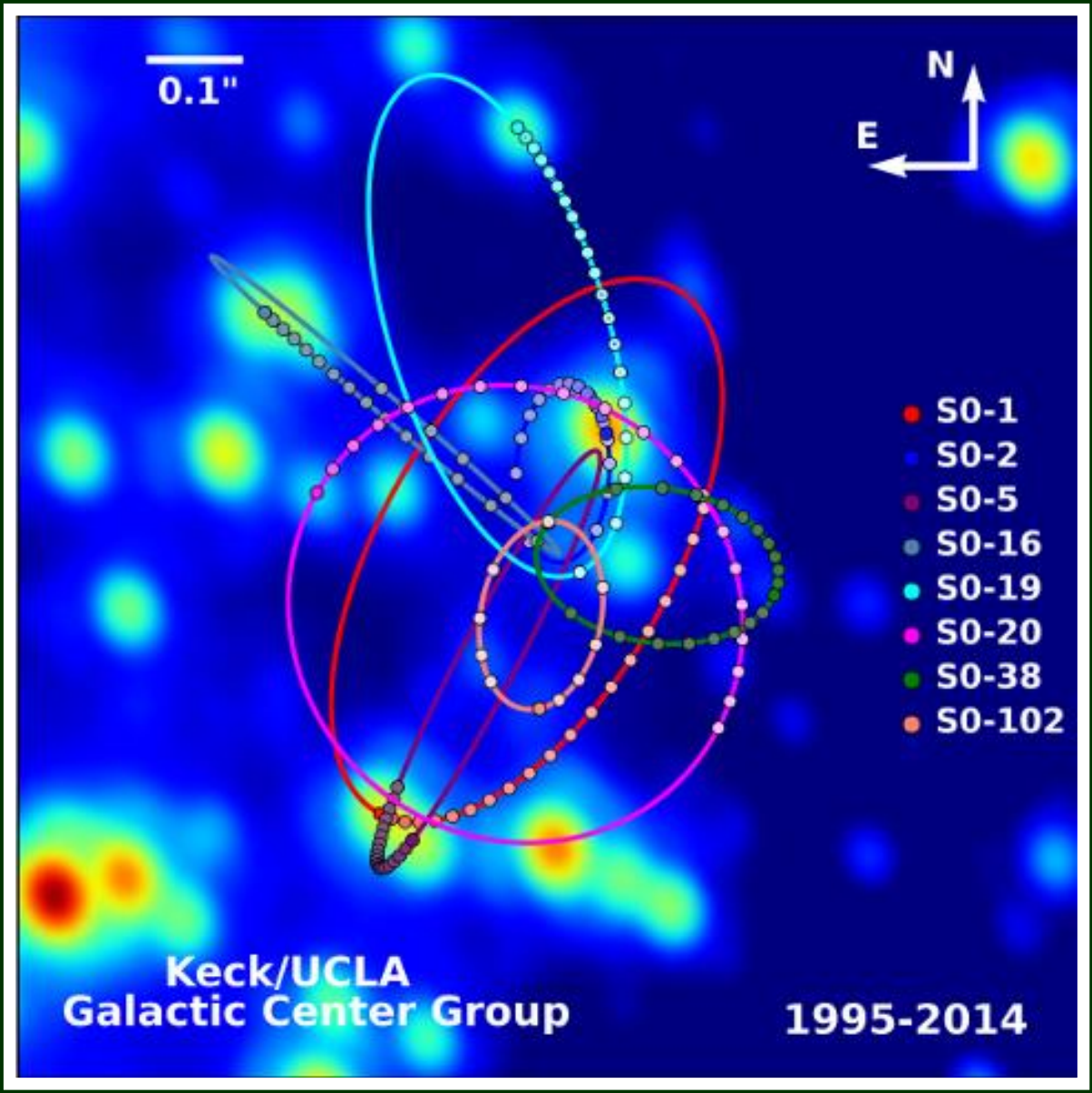


FIG. 2.—Examples of proper motions of H_2O maser spots in Sgr B2(N). Plotted are eastward (*left-hand panel*) and northward (*right-hand panel*) positions measured with respect to a reference maser feature as a function of time. A vertical scale of 1 mas is indicated in the upper left-hand corner. The data points are plotted with error bars and enclosed in rectangular boxes. In some cases the error bars are smaller than the symbol indicating the position of the maser spot. The vertical size of the rectangular boxes is 0.3 mas, a characteristic size of the maser spots. The horizontal size of the boxes is arbitrary.

Reid et al. 1988, ApJ, 330, 809

Determinación de la distancia Sol - Centro Galáctico

Estrellas en órbita en torno a Sgr A*



Estrellas alrededor de Sgr A*: animaciones

- http://www.astro.ucla.edu/~ghezgroup/gc/animations.html

UCLA Galactic Center Group

- http://www.mpe.mpg.de/6590570/Stellar-Orbits

Max-Planck-Institut

Galactic Center Research

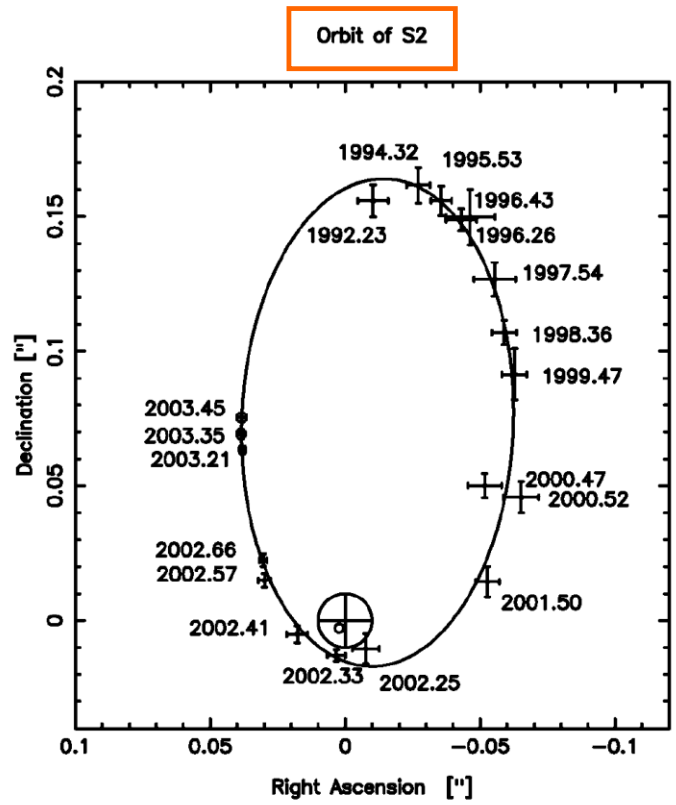
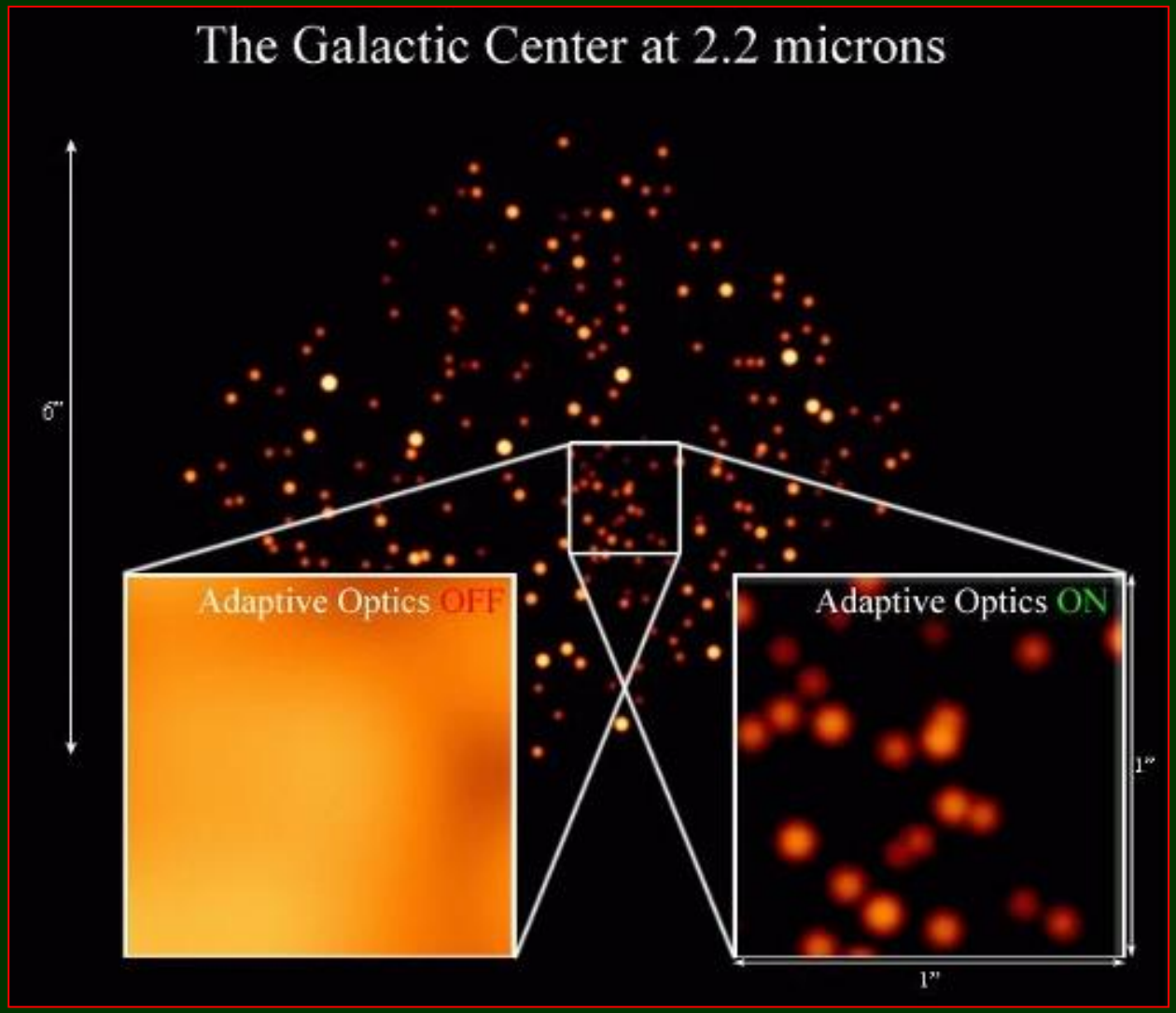


FIG. 1.—Position measurements of S2 in the infrared astrometric frame. Crosses (denoting 1 σ error bars) with dates mark the different position measurements of S2, taken with the MPE speckle camera SHARP on the NTT (between 1992 and 2001) and with NACO on the VLT (in 2002 and 2003). The continuous curve shows the best-fit Kepler orbit from Table 1, whose focus is marked as a small error circle. The focus of the ellipse is within a few milliarcseconds at the position of the compact radio source, which is marked by a large circled cross. The size of the cross denotes the ± 10 mas positional uncertainty of the infrared relative to the radio astrometric reference frame. [*See the electronic edition of the Journal for a color version of this figure.*]

Eisenhauer et al. 2003
ApJ 597, L121

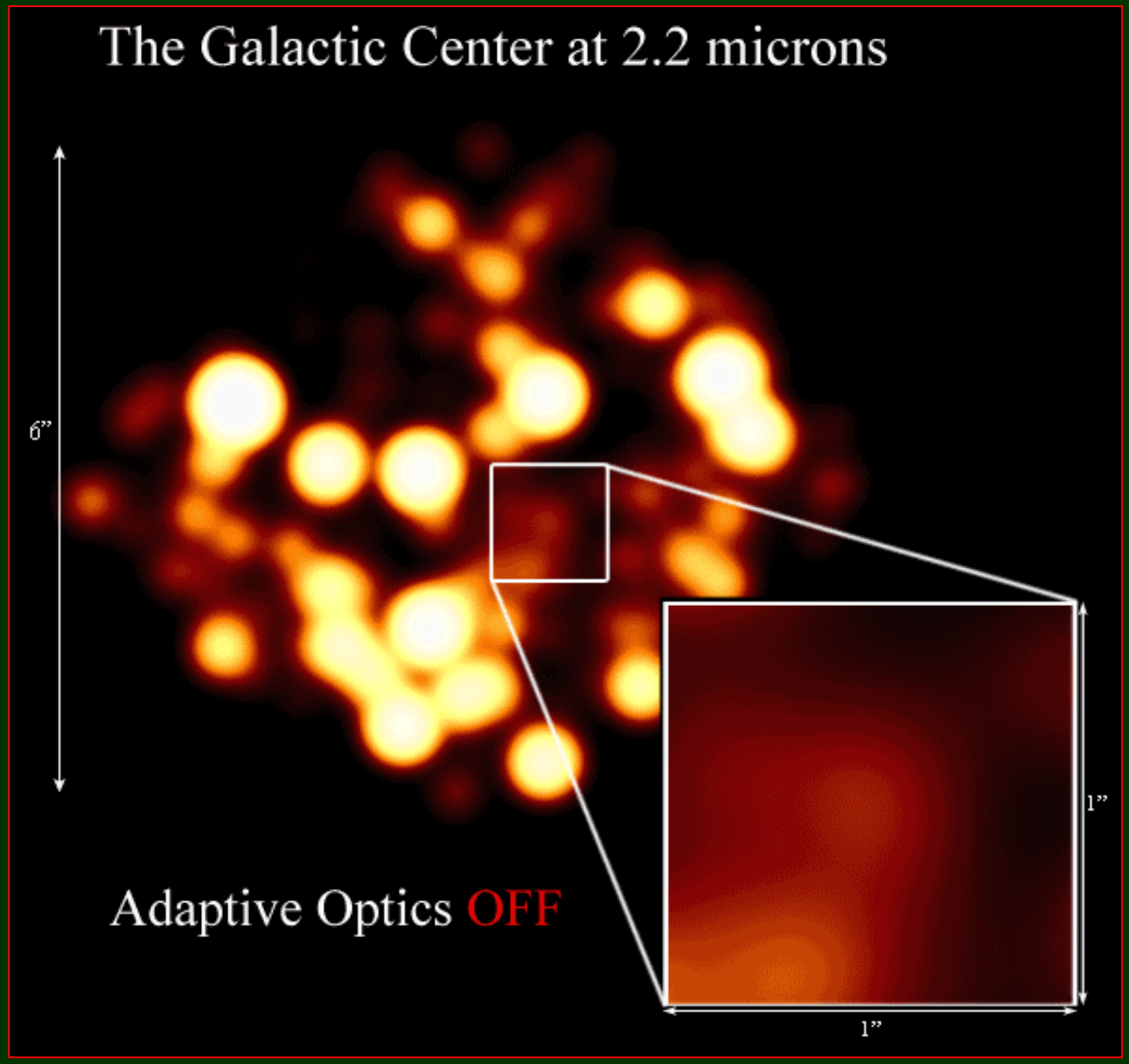
The two Keck Telescopes on Mauna Kea, Hawaii, observing the galactic center: The lasers are used to create an artificial star in Earth's upper atmosphere, which is then employed to measure the blurring effects of the lower atmosphere (that makes the stars twinkle in the night sky). The blurring gets corrected in real time with the help of a deformable mirror. This is the adaptive optics technique.

Óptica Adaptativa



UCLA Galactic Center Group

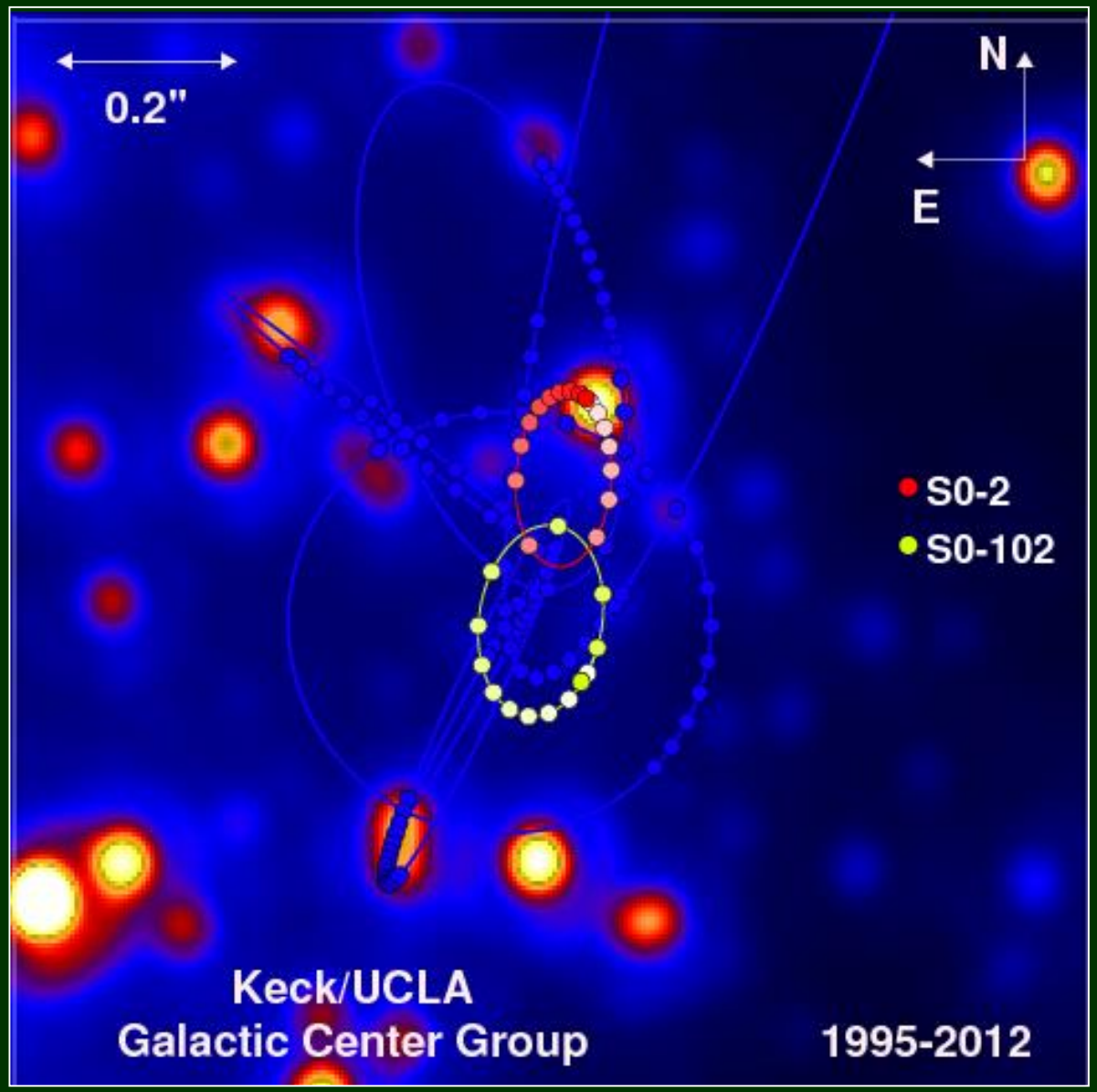
Óptica Adaptativa



UCLA Galactic Center Group / W. M. Keck Observatory Laser Team

This animation shows observations of the Galactic Center with and without Adaptive Optics, illustrating the resolution gain.

Descubrimiento de la estrella con período conocido más corto (11.5 años) en el Centro Galáctico: S0-102



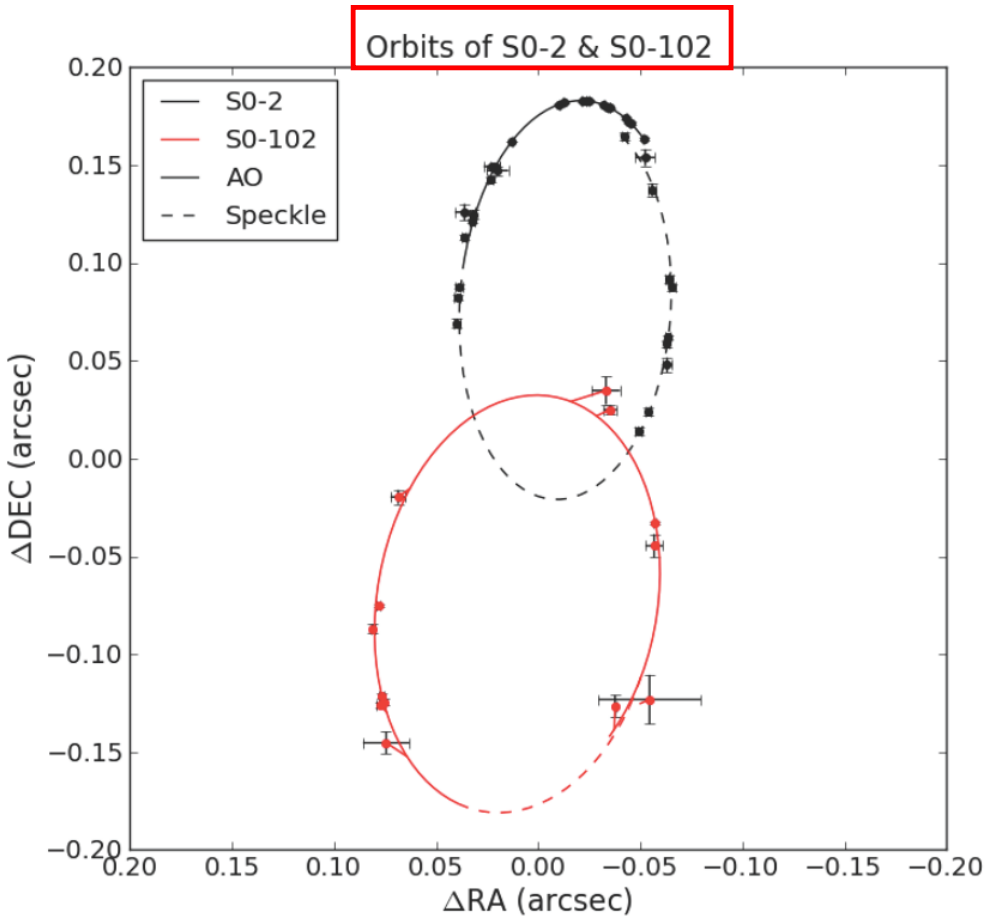


Figure 2 The orbits of S0-2 (black) and S0-102 (red). The data points and the best fits are shown. Both stars orbit clockwise. The dashed lines represent the part of the orbits that have been observed with Speckle data, the solid lines indicate adaptive optics observations. The data points for S0-2 range from the year 1995 to 2012, S0-102's detections range from 2000 to 2012. The connecting lines to the best fit visualize the residuals. Note that while the best-fit orbits are not closing, the statistically allowed sets of orbital trajectories are consistent with a closed orbit. S0-102 has an orbital period of 11.5 years, 30% shorter than S0-2, the previously known shortest-period star.

Meyer et al. 2012, Science 338, 84

Table 1. Orbital elements for S0-102 [a]

Parameter [Unit]	Value
S0-102's orbital parameters	
Period [years]	11.5 ± 0.3
Time of Closest Approach [year]	2009.5 ± 0.3
Eccentricity	0.68 ± 0.02
Inclination[b,c] [degrees]	151 ± 3
Angle to Periapse [degrees]	185 ± 9
Position Angle of the Ascending Node[c] [degrees]	175 ± 5
Parameters of the potential[d]	
Mass [10^6 M_{Sun}]	4.1 ± 0.4
Distance [kpc]	7.7 ± 0.4

Meyer et al. (2012)

Imagen de las estrellas S0-2 y S0-102

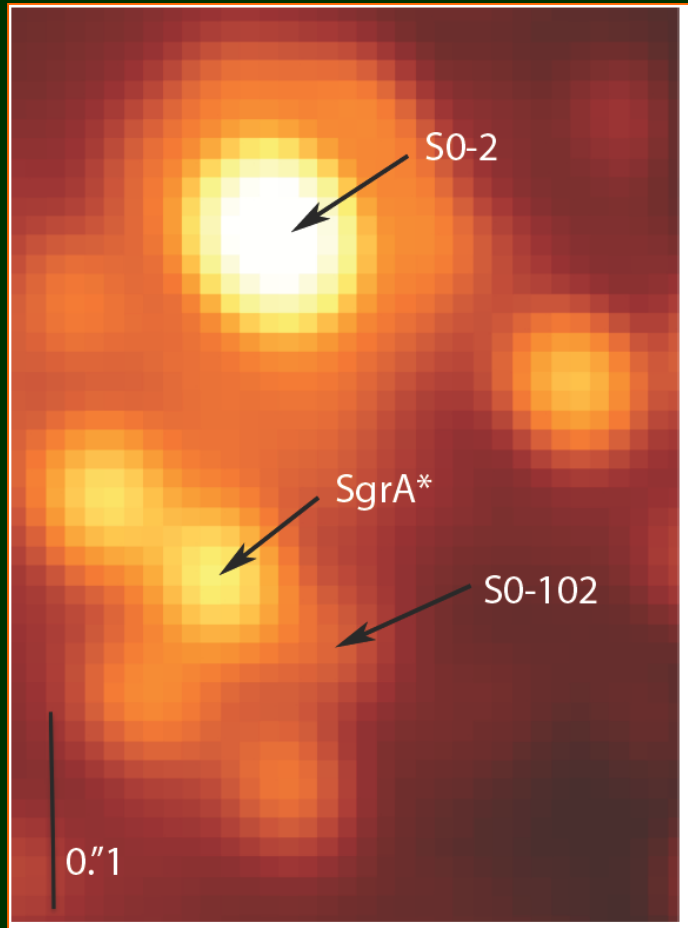
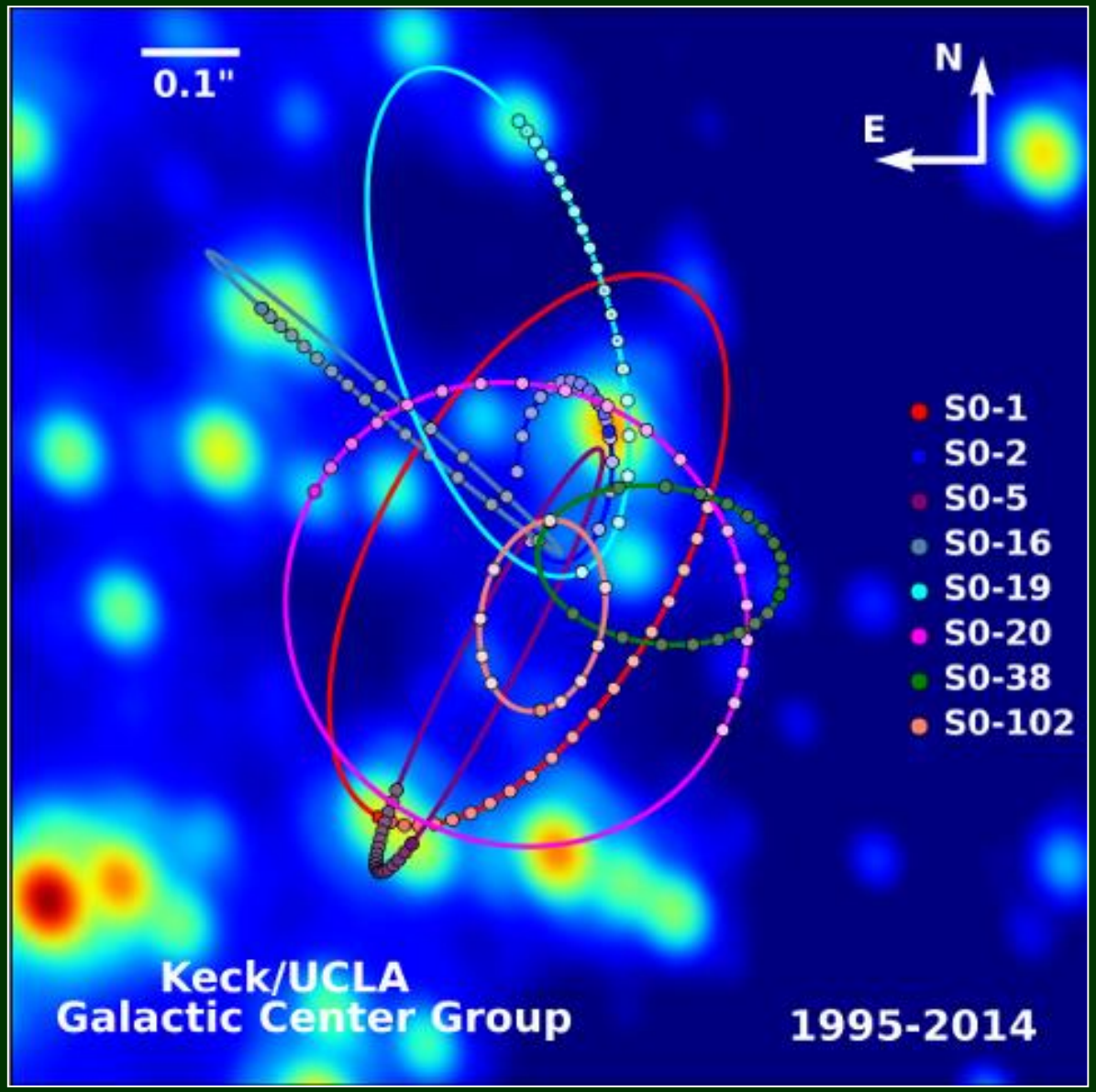


Figure 1 A Keck/NIRC2 adaptive optics image from May 2010 showing the short-period star S0-102, which is besides S0-2 the only star with full orbital phase coverage, and the electromagnetic counterpart of the black hole, Sgr A*. The image was taken at a wavelength of 2.12 μm and shows the challenge of detecting S0-102, which is 16 times fainter than S0-2 and lies in this crowded region.

Meyer et al. (2012)



The orbits of stars within the central 1.0 X 1.0 arcsec of our Galaxy. These orbits provide the best evidence yet for a supermassive black hole. While every star in this image has been observed to move since 1998, estimates of orbital parameters are best constrained for stars that have been observed through at least one turning point of their orbits.