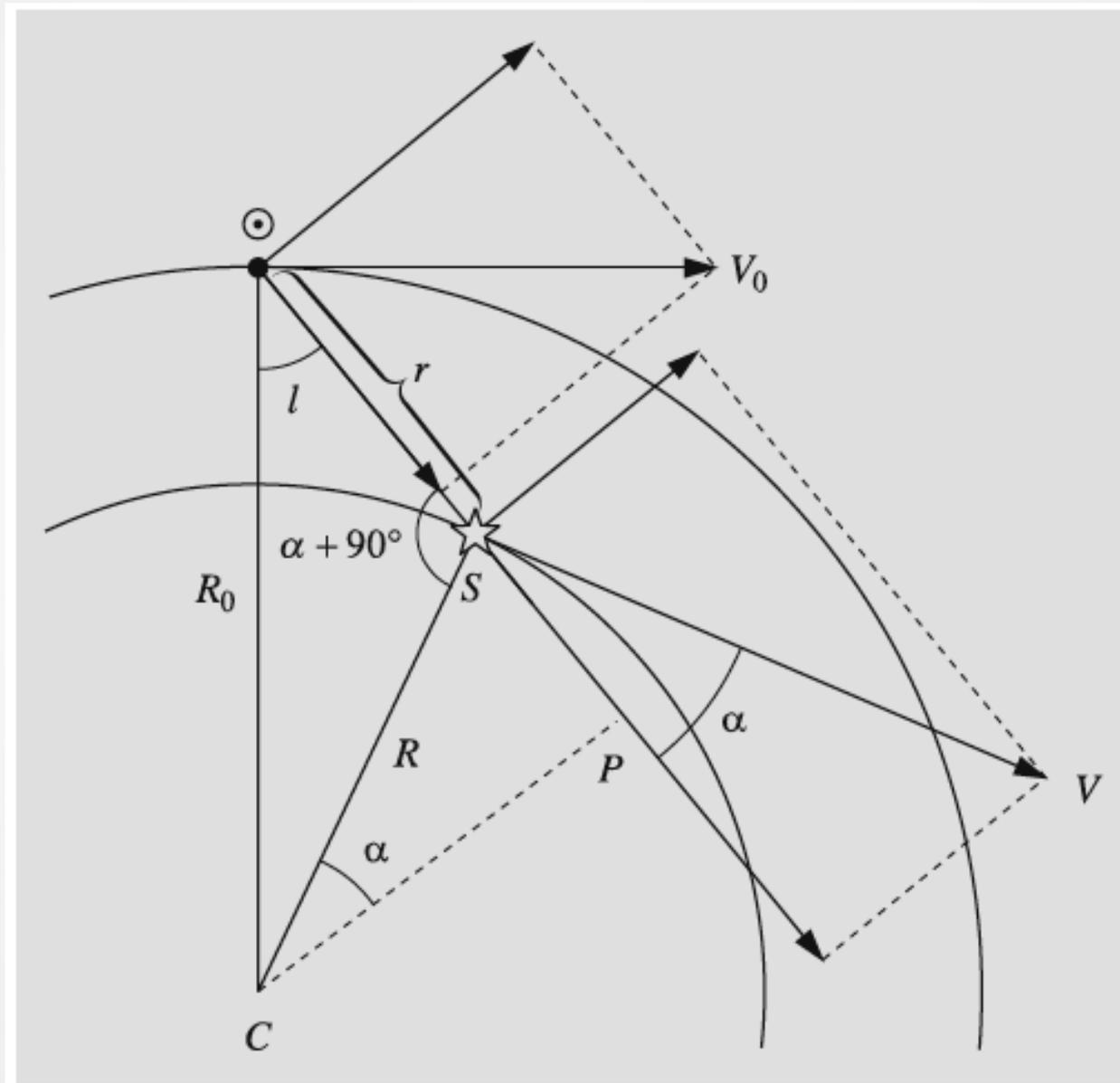


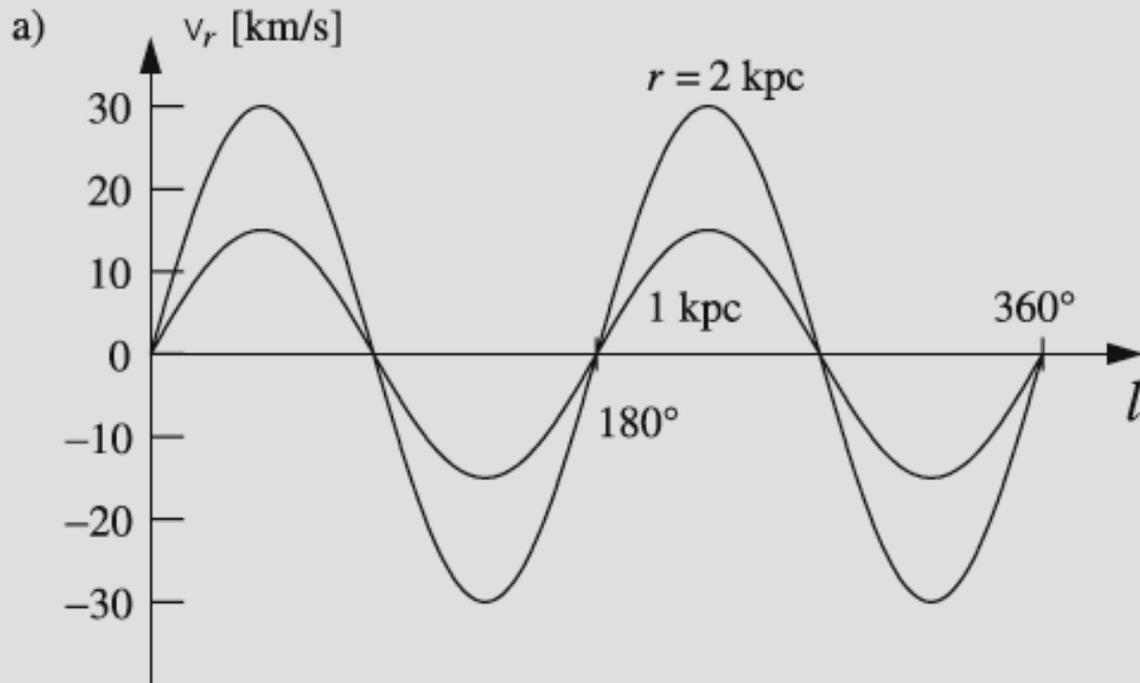
Struktura Galaksije

Dinamika galaktičnega diska

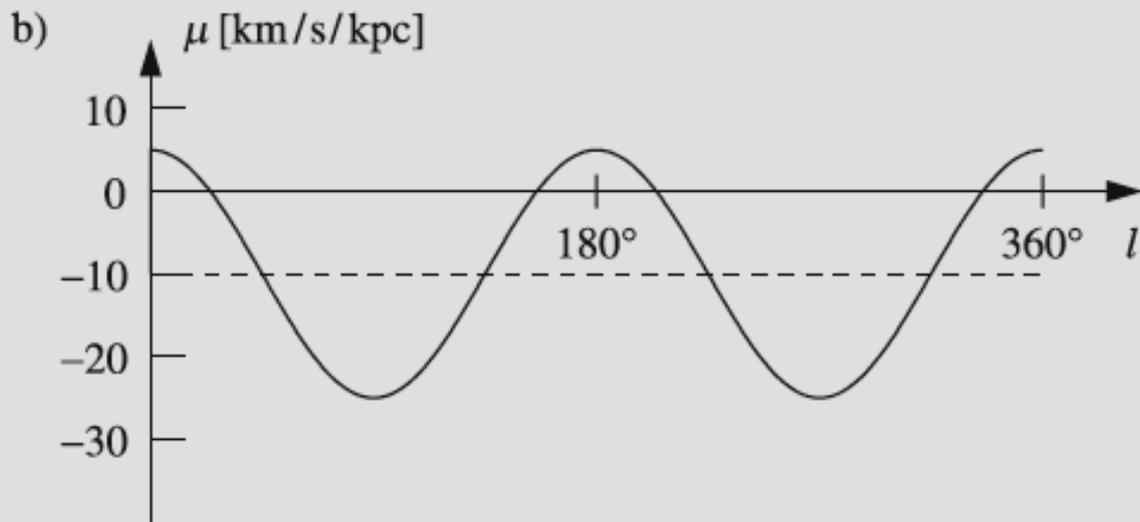
Oortovi konstanti



iz knjige “Fundamental Astronomy”



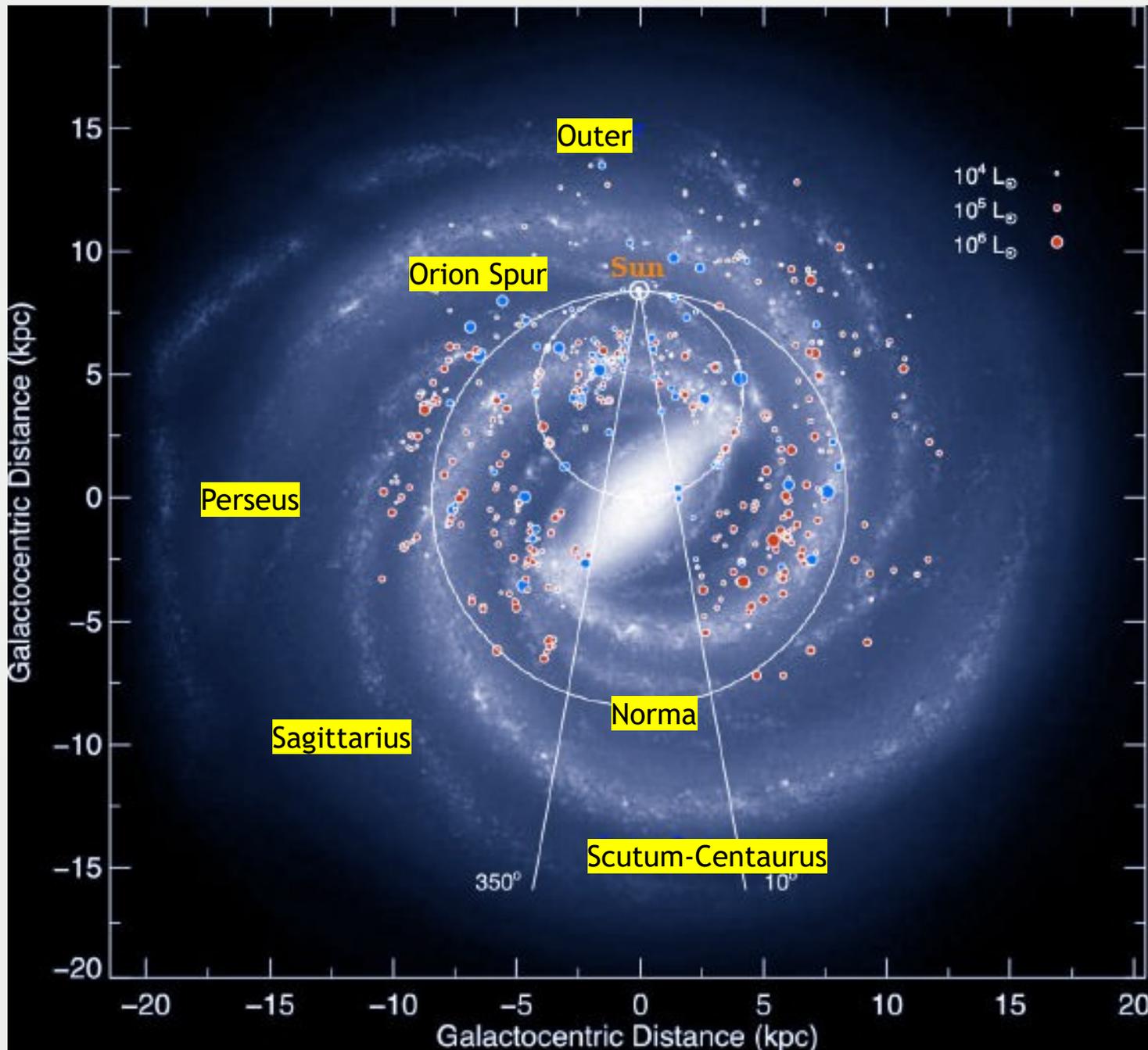
$$v_r = A \cdot r \cdot \sin 2l$$



$$v_t = A \cdot r \cdot \cos 2l + B r$$

$$\mu = A \cdot \cos 2l + B$$

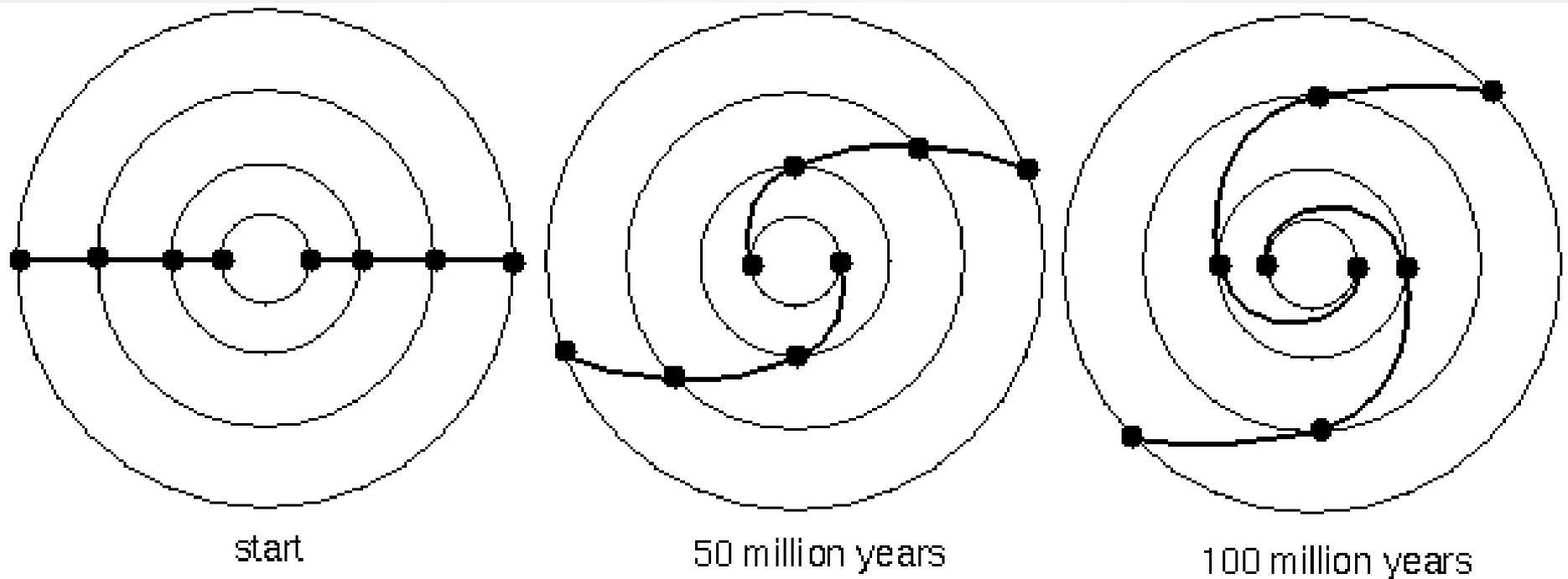
Spiralni rokavi



- območja kopic z mladimi zvezdami
- območja HII

Zemljevid spiralne strukture naše Galaksije (Urquhart et al. 2013)
(avtorstvo: Urquhart et al. 2013, R. Hurt, the Spitzer Science Center, R. Benjamin)

Diferencialna rotacija zvezd

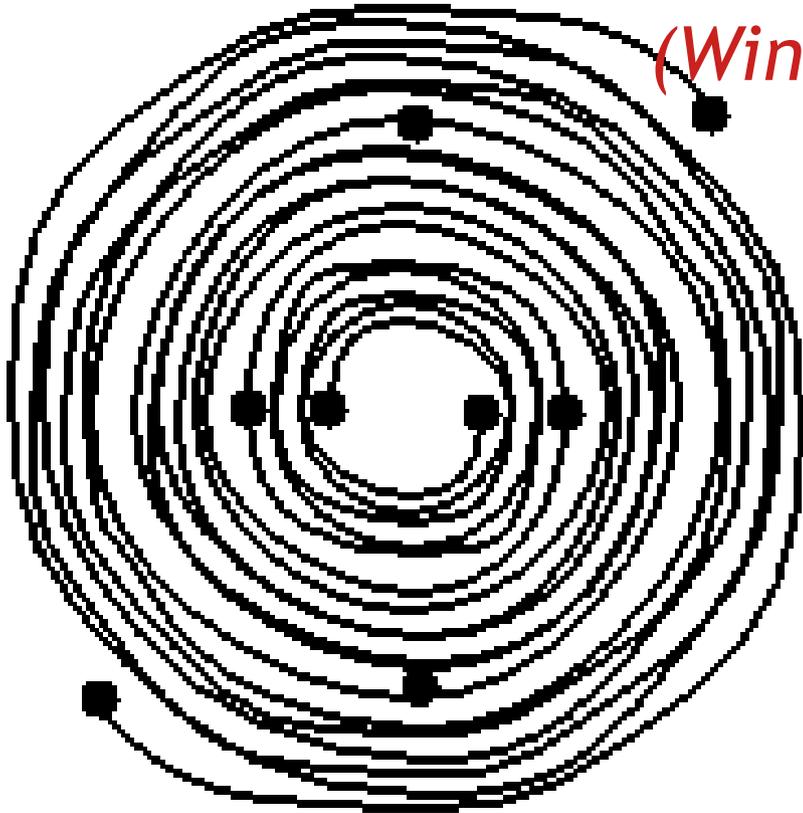


Differential rotation: stars near the center take less time to orbit the center than those farther from the center. Differential rotation can create a spiral pattern in the disk in a short time.

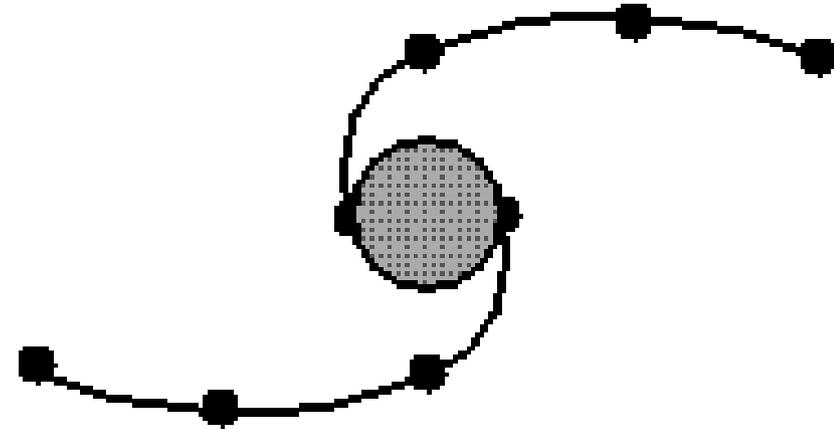
Diferencialna rotacija bi lahko bila vzrok nastanka spiralnih rokavov, vendar...

Dilema navijanja rokavov

(Winding dilemma)



Prediction: 500 million years

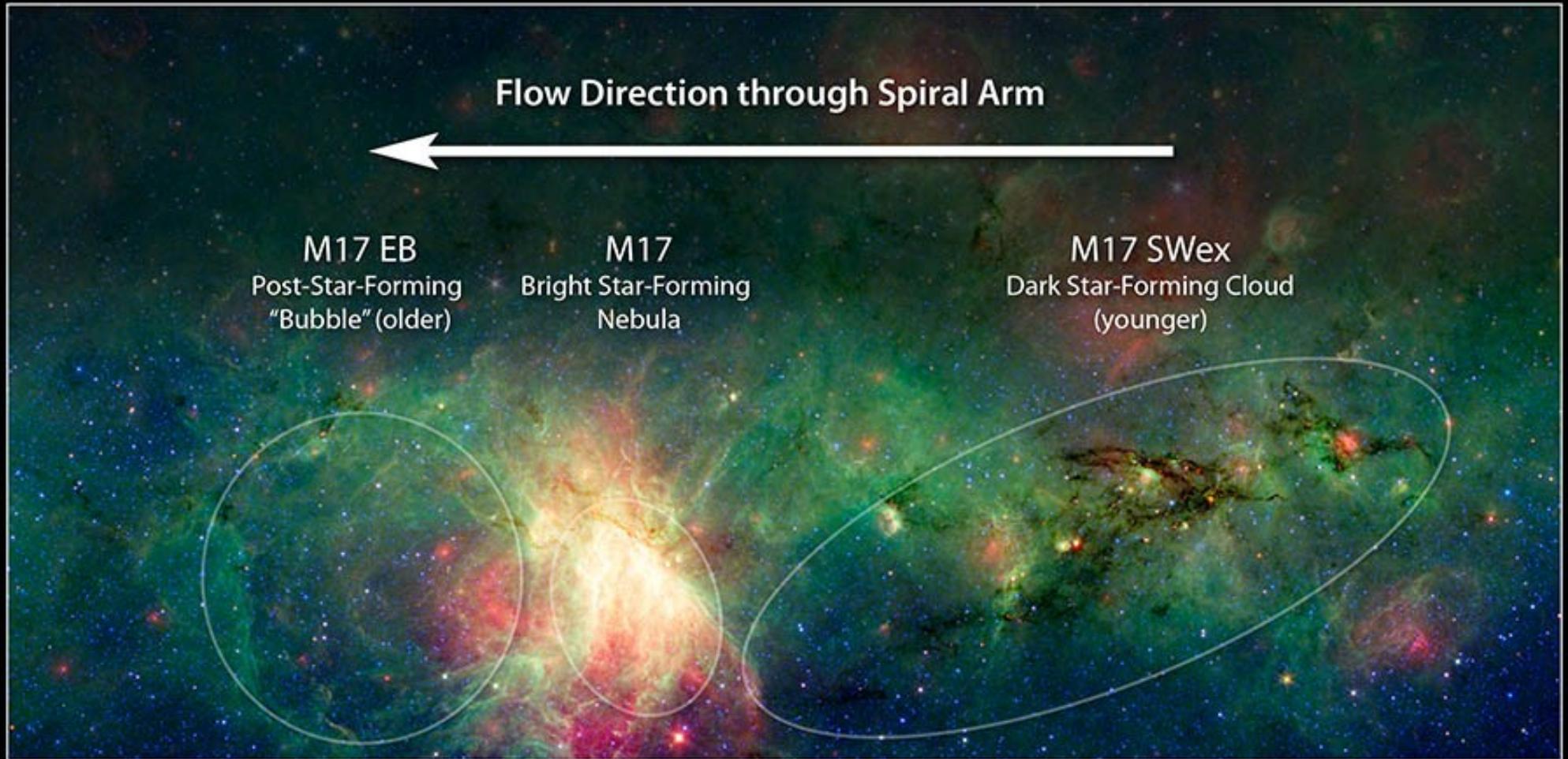


Če bi bila diferencialna rotacija vzrok nastanka spiralnih rokavov bi spiralne strukture po krajšem času izginile!

Observation: 15,000 million years

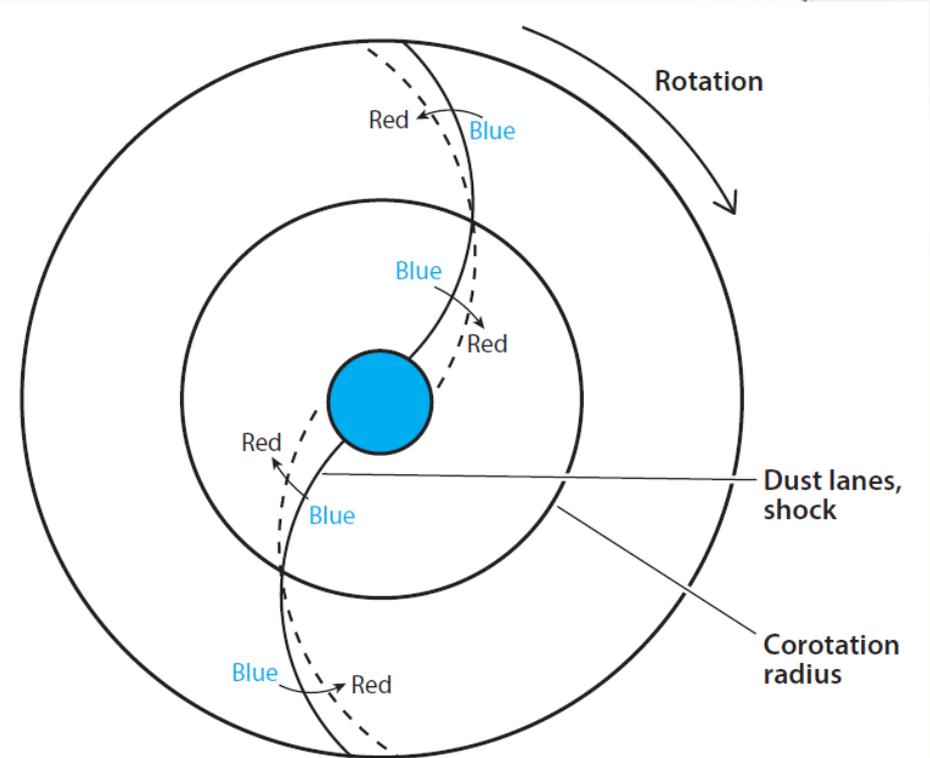
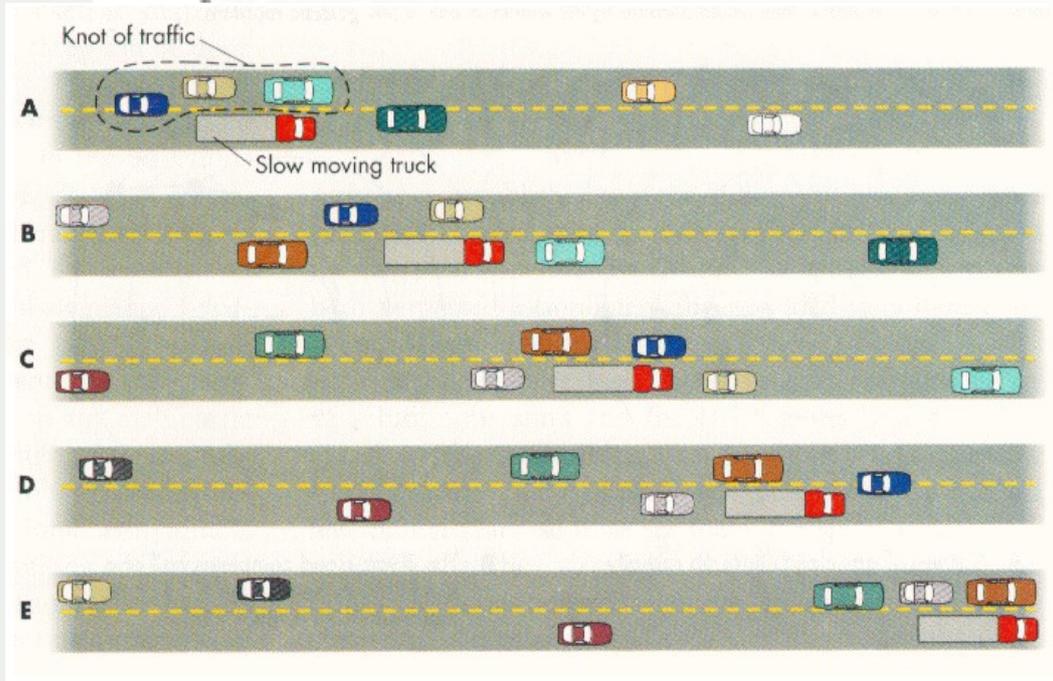
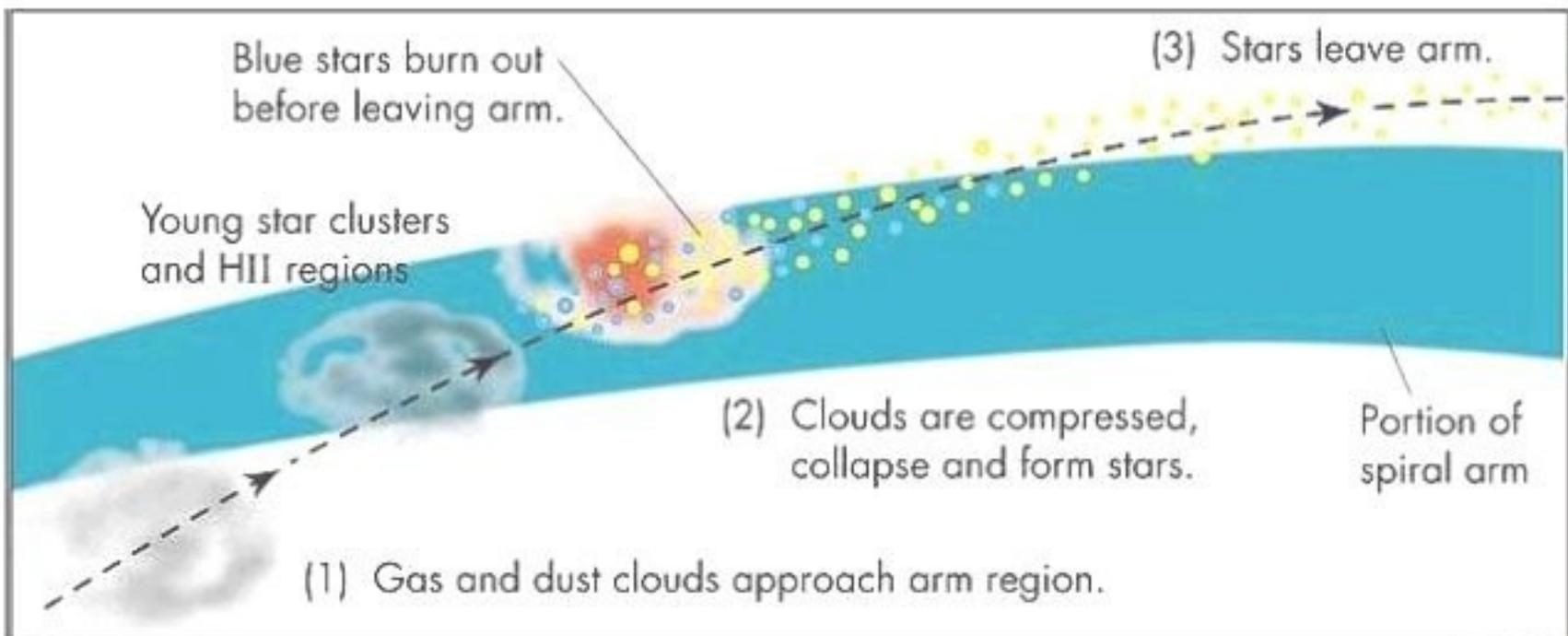
The “winding problem”: because of differential rotation, the spiral arms should be so wound up after a short time that the spiral structure has disappeared. Observation contradicts the prediction. What keeps the spirals loose?

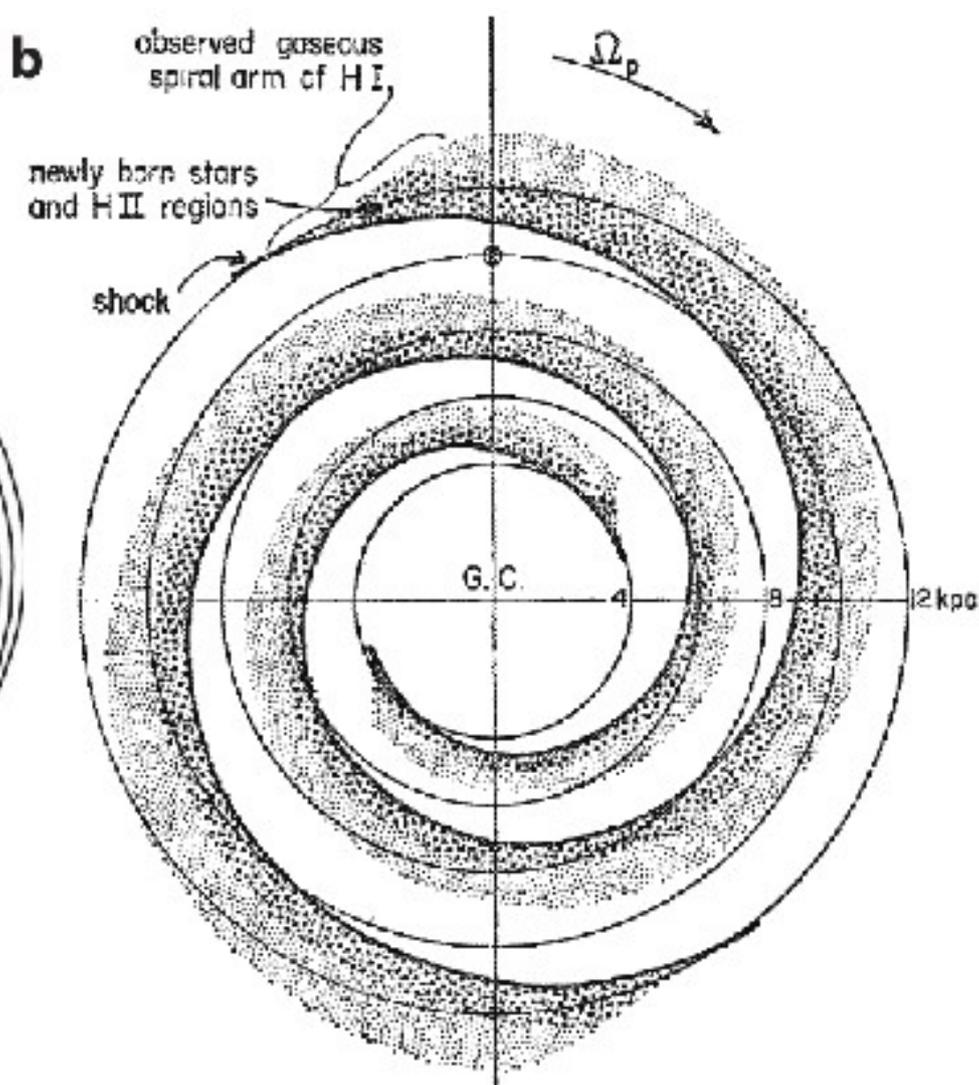
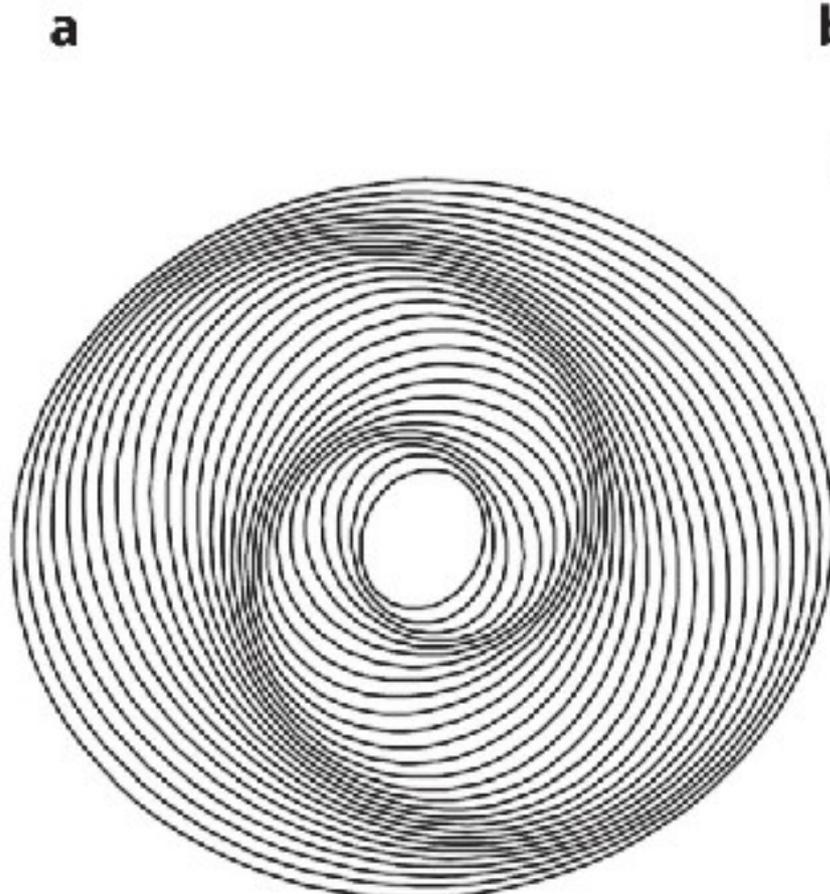
Prehod skozi spiralne rokave



Spiral Arm Star Formation Sequence
NASA / JPL-Caltech / M. Povich (Penn State Univ.)

Spitzer Space Telescope • IRAC-MIPS
sig10-009





Numerične simulacije spiralnih rokavov

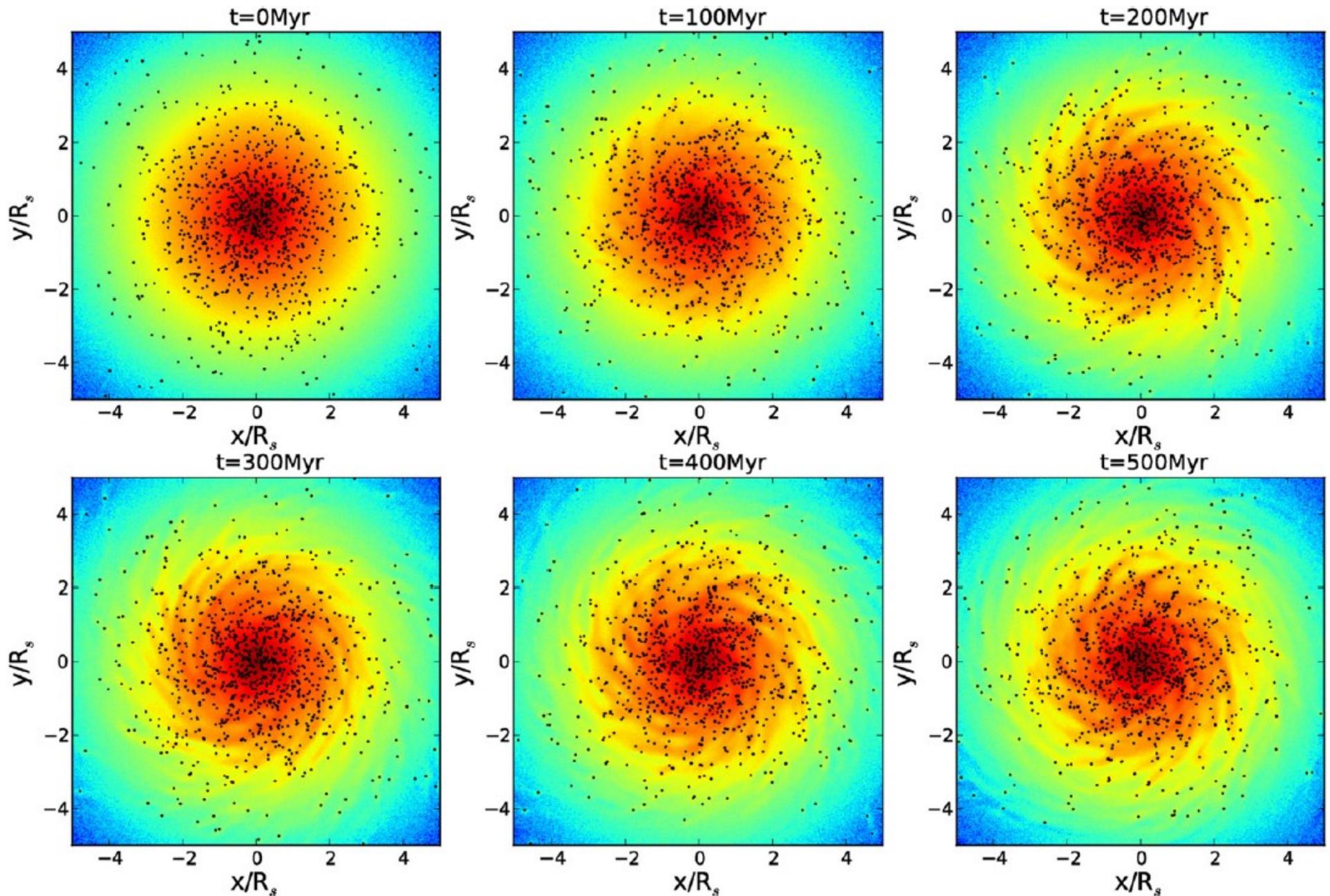


Figure 3. Time sequence of an N -body experiment in which a self-gravitating disk of 100 million stars seen face-on embedded in a dark Milky-Way-sized halo is run with 1000 giant molecular clouds (represented with the black dots) which are randomly distributed within the disk and are assumed to be corotating on circular orbits with the disk stars. The giant molecular clouds act as perturbers and the live disk dynamically responds to the presence of these perturbers by developing features which resemble multi-armed structures in galaxies. Each panel displays a region 30 kpc on a side at the times indicated.

Struktura Galaksije

Zvezdni halo in središčna odebelitev

Zvezdni halo

Razporeditev kroglastih zvezdnih kopic

po letu 1917 ameriški astronom **H. Shapley** meri razporeditev kroglastih zvezdnih kopic

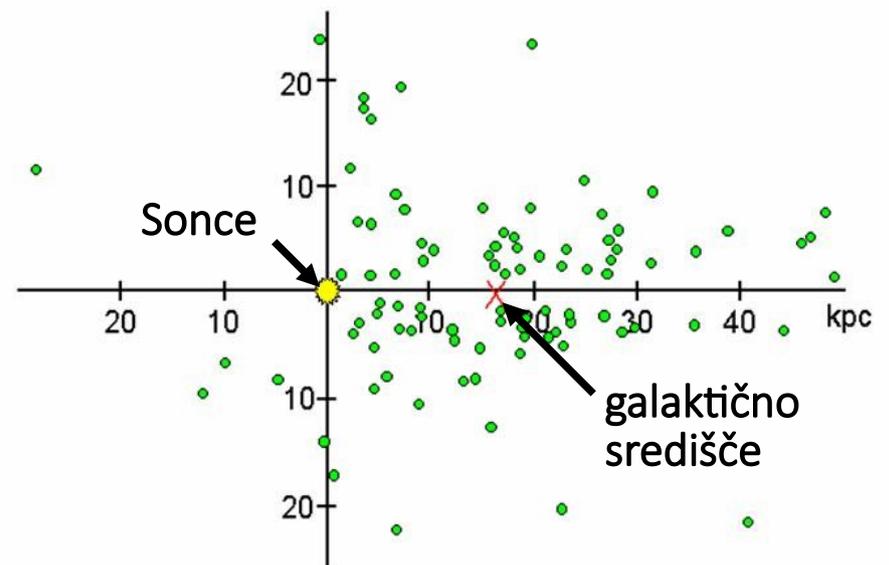
polmer:
50.000 svetlobnih let

središče Galaksije
v ozvezdju Strelca

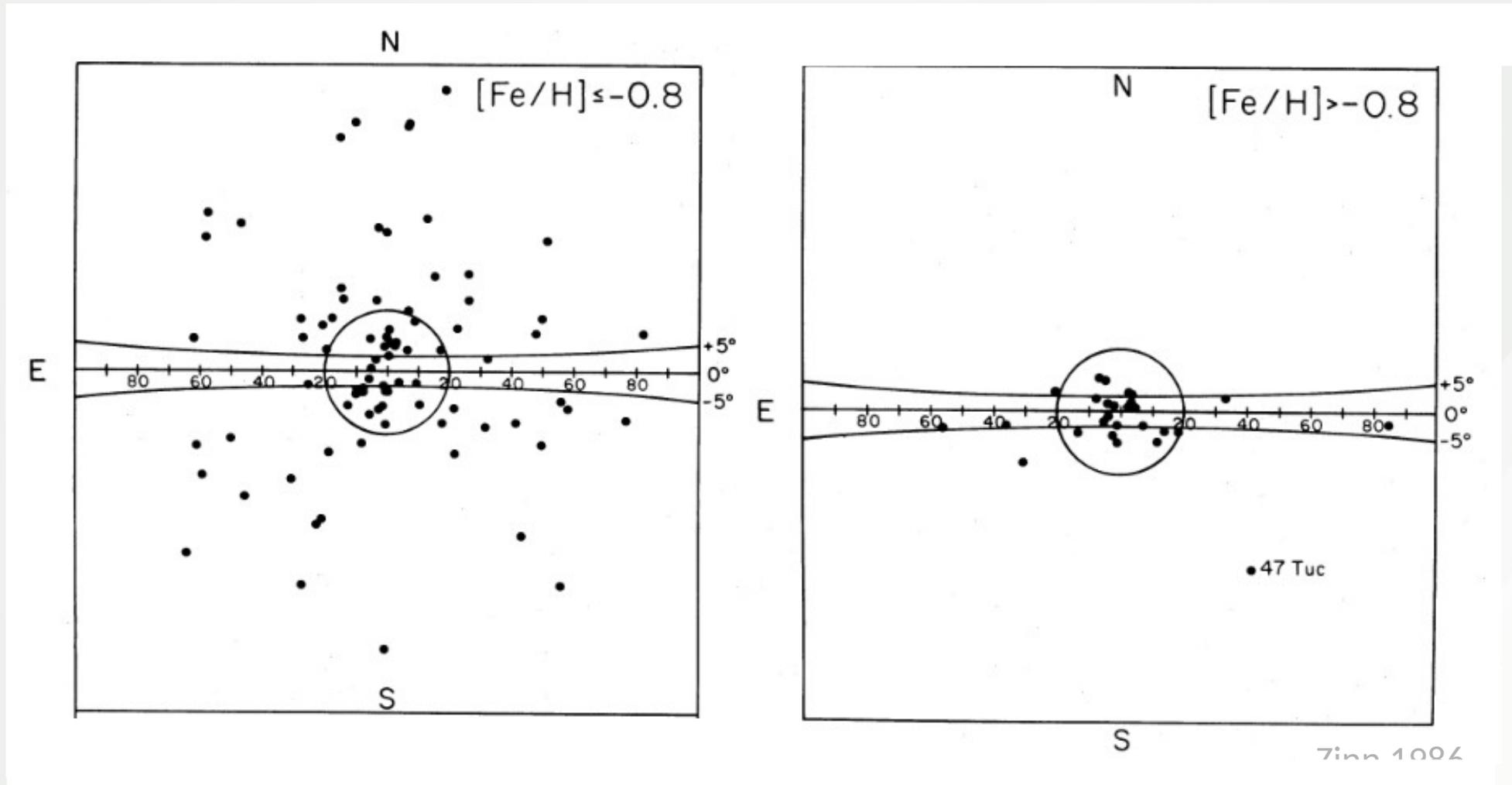
Ugotovitve:

- niso enakomerno razporejene v vse smeri
- kjer so številnejše, so tudi manjše in temnejše
- krogelno razporejene s središčem oddaljenim 35.000 svetlobnih let v smeri Strelca
- oddaljenosti kroglastih kopic izmeri s spremenljivimi zvezdami
- izmeri polmer Galaksije

Shapley's Globular Cluster Distribution



Zvezdni halo



Razmerje kemične zastopanosti

$$[Fe/H] = \log\left(\frac{N_{Fe}}{N_H}\right)_* - \log\left(\frac{N_{Fe}}{N_H}\right)_\odot$$

Struktura Galaksije

Središčna črna luknja

Viri: Jones, Lambourne (Chap. 1), Maoz (Chap. 6)

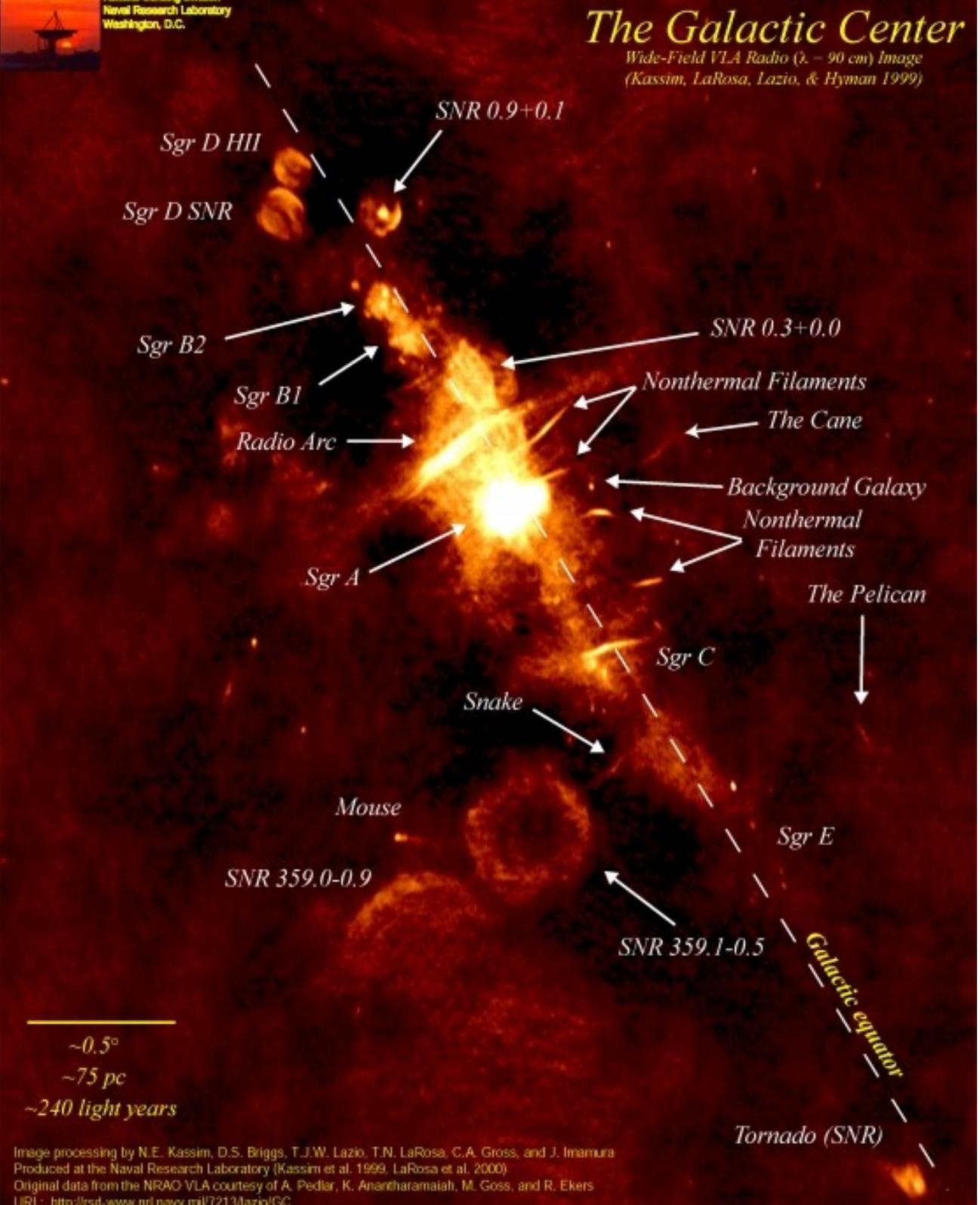
Prosojnice so delno prirejene po starejših prosojnicah prof. dr. Andreje Gomboc



Naval Research Laboratory
Washington, D.C.

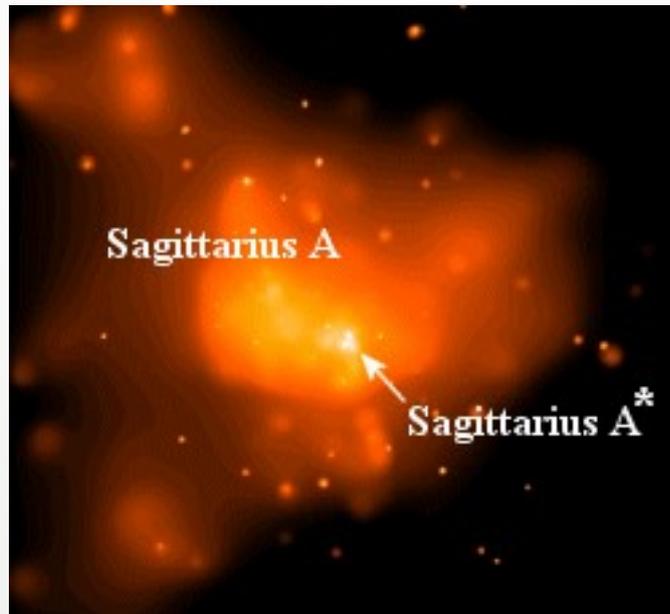
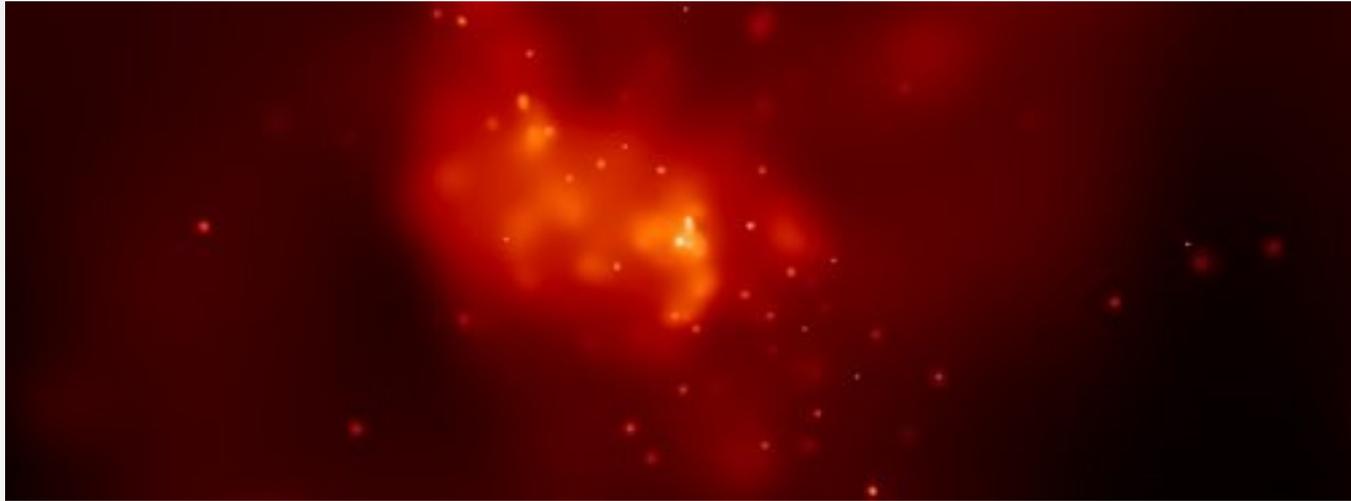
The Galactic Center

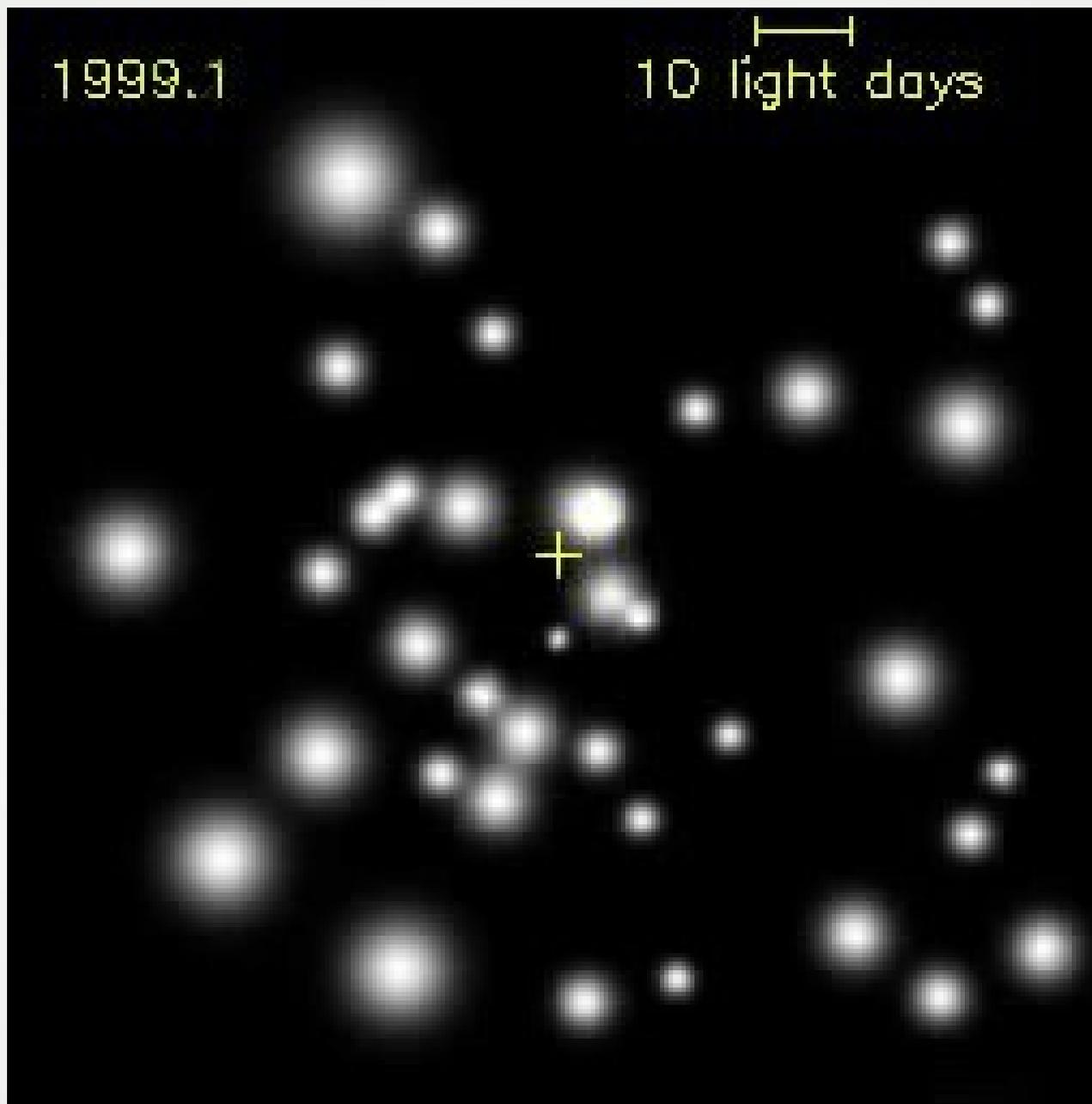
Wide-Field VLA Radio ($\lambda = 90$ cm) Image
(Kassim, LaRosa, Lazio, & Hyman 1999)



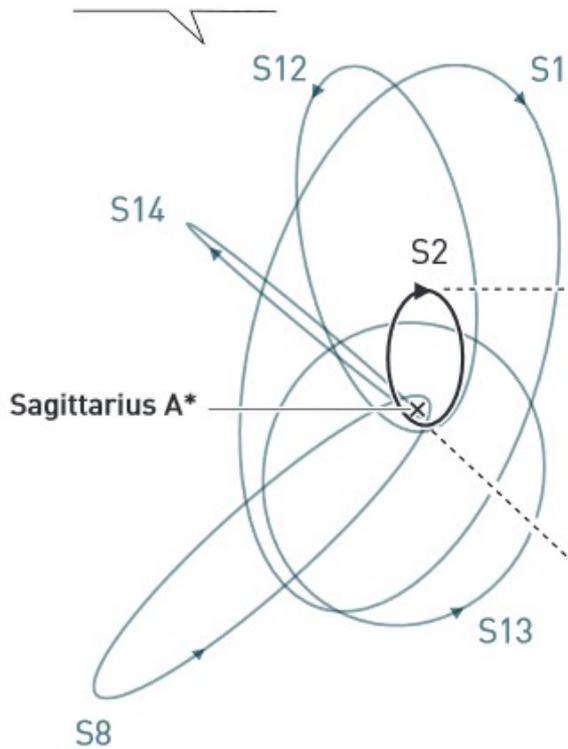
~0.5°
~75 pc
~240 light years

Image processing by N.E. Kassim, D.S. Briggs, T.J.W. Lazio, T.N. LaRosa, C.A. Gross, and J. Imamura
Produced at the Naval Research Laboratory (Kassim et al. 1999, LaRosa et al. 2000)
Original data from the NRAO VLA courtesy of A. Pedlar, K. Anantharamaiah, M. Goss, and R. Ekers
URL: <http://rsd-www.nrl.navy.mil/7213/lazio/GC>

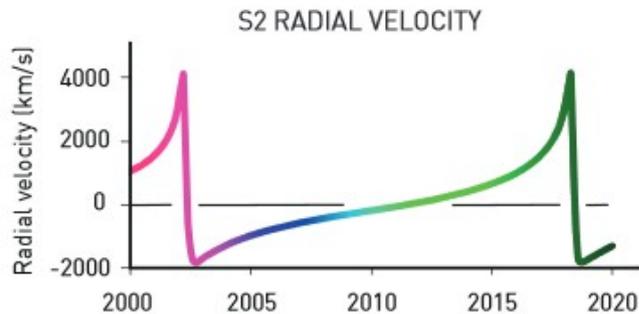
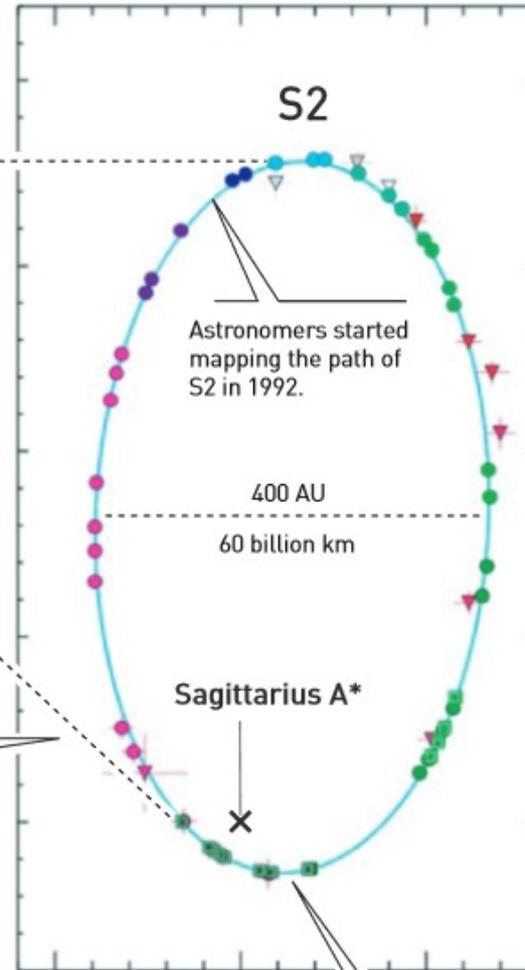




Some of the measured orbits of stars close to Sagittarius A* at the centre of the Milky Way.



Astronomers were able to map an entire orbit of less than 16 years for one of the stars, S2 (or S-02). The closest it came to Sagittarius A* was about 17 light hours (more than 10,000 million kilometres).



The S2 star's radial velocity increases as it approaches Sagittarius A* and decreases as it moves away along its elliptical orbit. Radial velocity is the component of the star's velocity that is in our line of sight.

Closest to Sagittarius A* (in 2002 and 2018), S2 reaches its maximum velocity of 7 000 km/s.

Nobelova nagrada 2020

Roger Penrose
(črne luknje iz splošne teorije relativnosti)

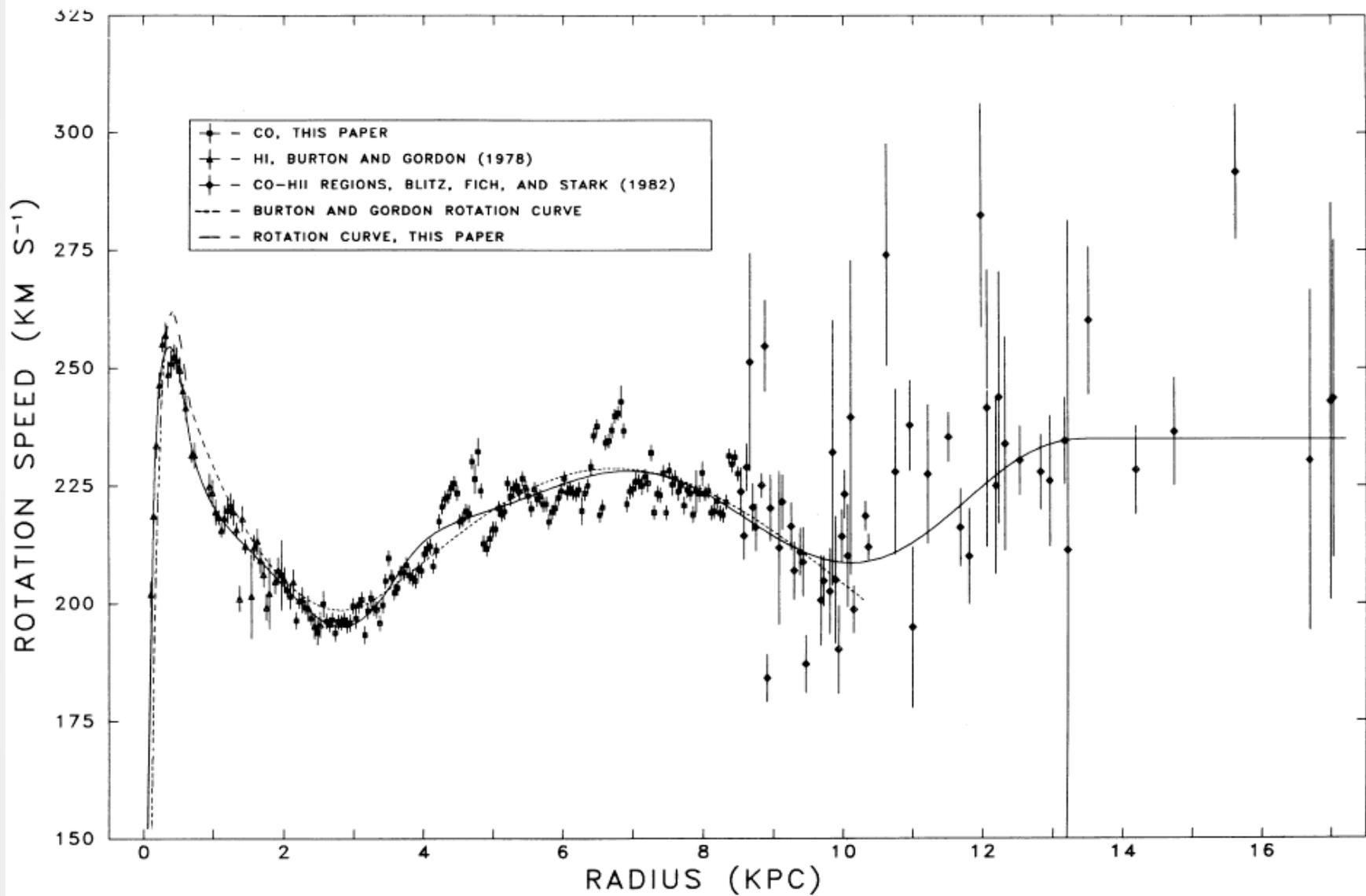
Reinhard Genzel
Andrea Ghez
(supermasivni objekt v središču Galaksije)

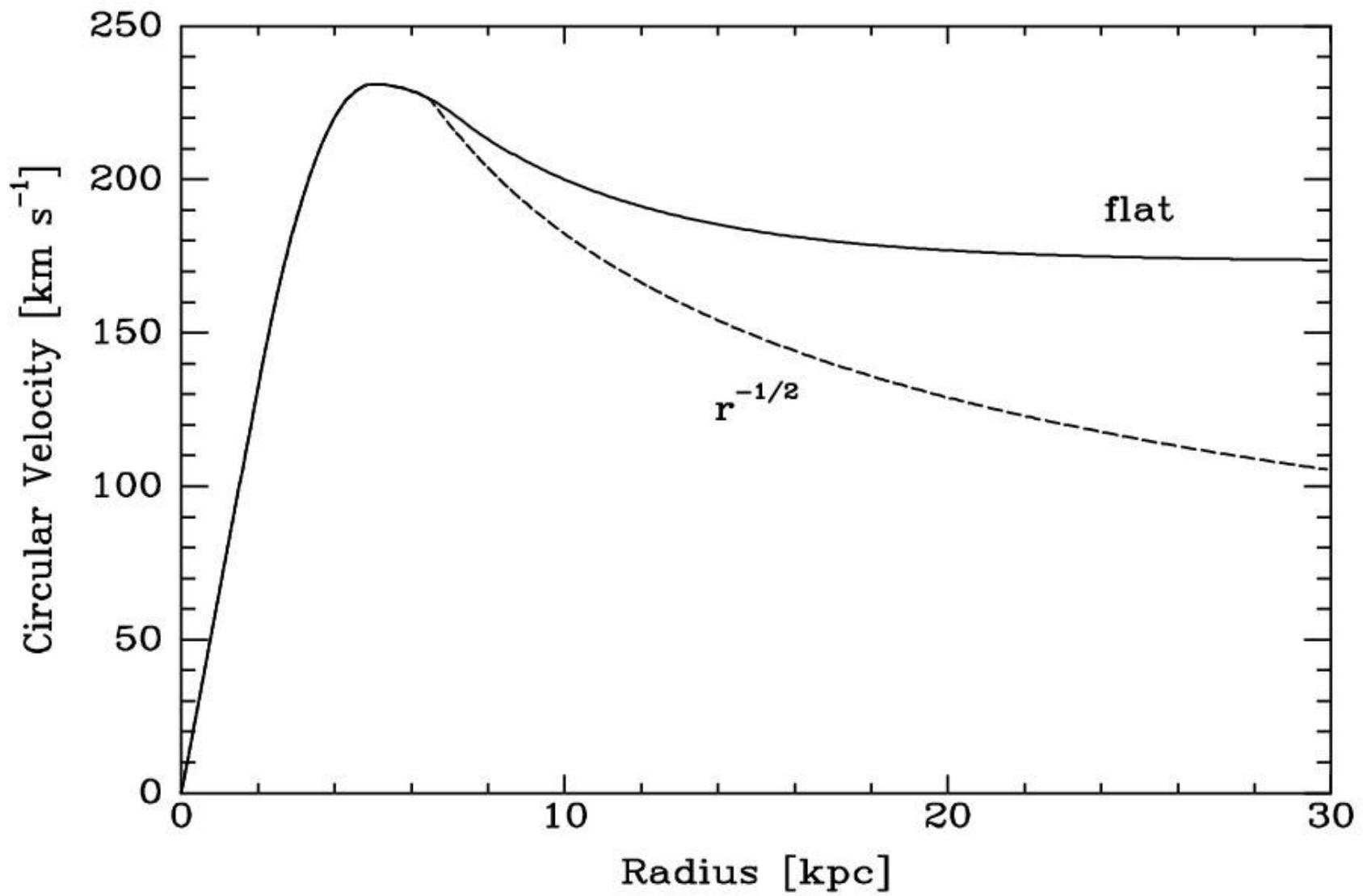
Struktura Galaksije

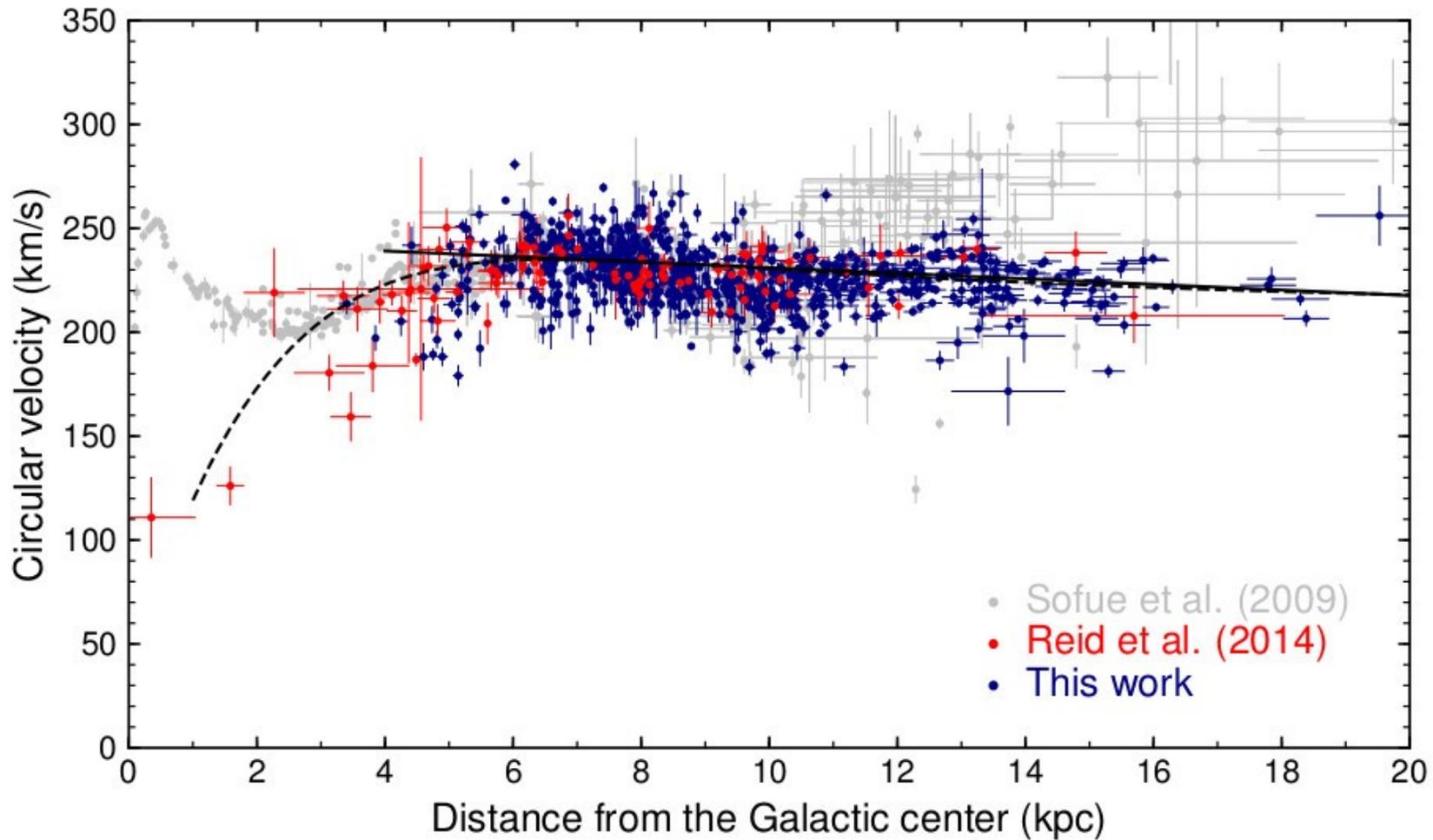
Halo temne snovi

Viri: Jones, Lambourne (Chap. 1), Kartunnen (Chap. 4.5, 15), Maoz (Chap. 5, 6)

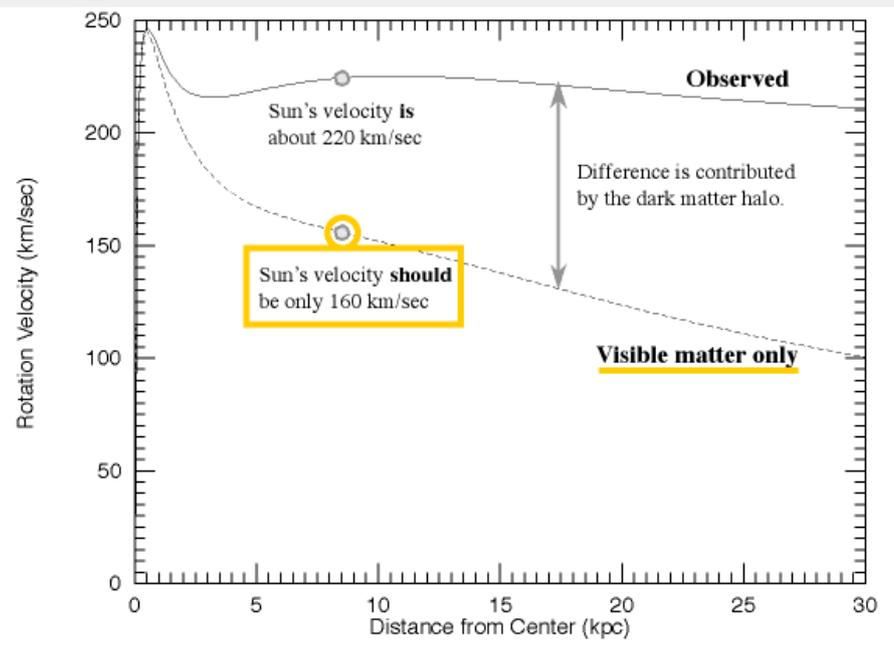
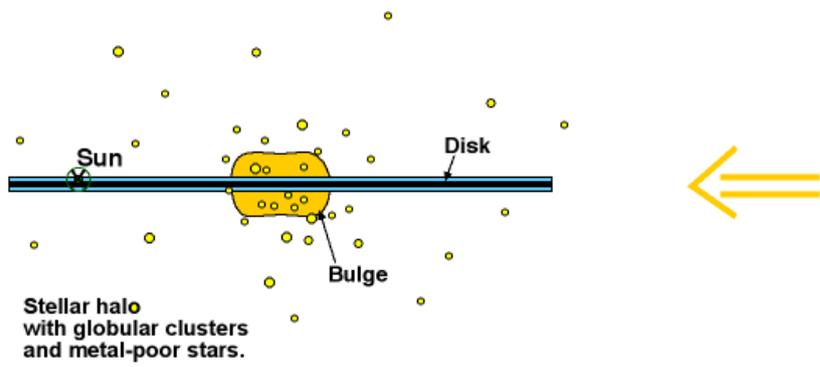
Prosojnice so delno prirejene po starejših prosojnicah prof. dr. Andreje Gomboc



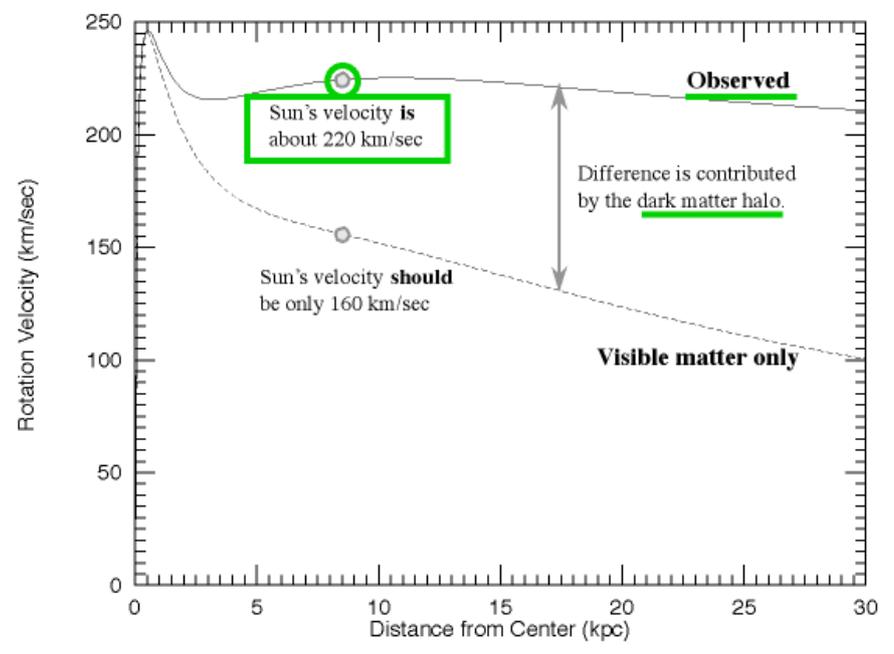
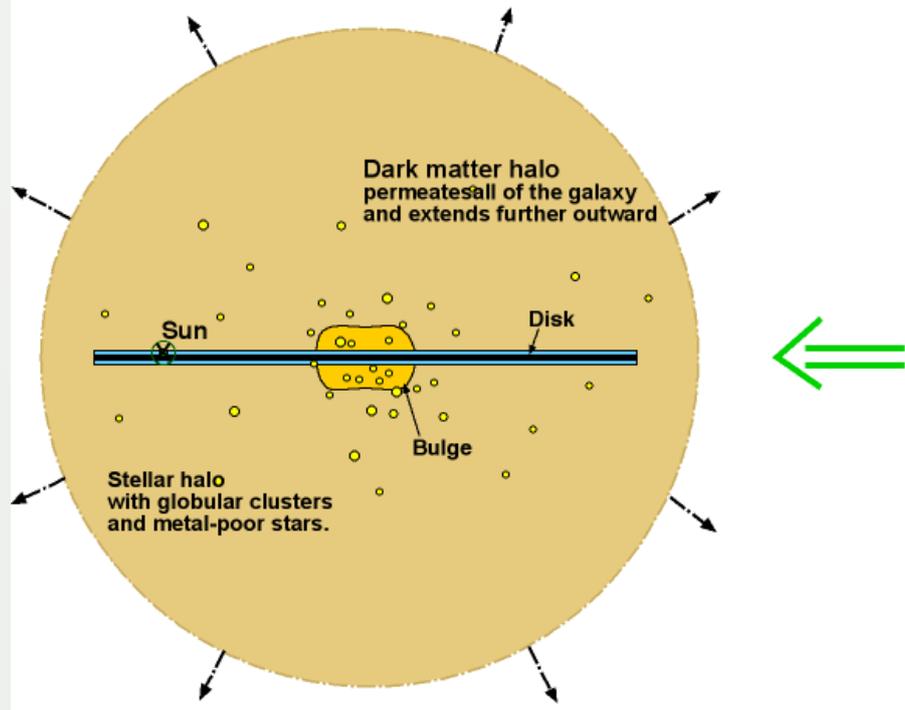




Rotation curve of the Milky Way for Cepheids. Red data points represent high-mass star-forming regions (Reid et al. 2014). Gray data points are taken from Sofue et al. (2009). Solid and dashed lines show the best-fitting models (linear and universal, respectively). *Mroz et al. (2019)*



Rotation curve shows that there is "extra" gravity.



The gravity of the visible matter in the Galaxy is not enough to explain the high orbital speeds of stars in the Galaxy. For example, the Sun is moving about 60 km/sec too fast. The part of the rotation curve contributed by the visible matter only is the bottom curve. The discrepancy between the two curves is evidence for a **dark matter halo**.

Struktura Galaksije

Narava temne snovi

Viri: Jones, Lambourne (Chap. 1), Maoz (Chap. 6)

Narava temne snovi

- plin?
- prah?
- masivni kompaktni objekti v haloju?
- osnovni delci?