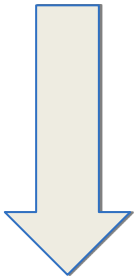
The Weird Universe



Astro(nomy and physics)

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Indian Institute of Technology Bombay

What the lecture is about?

- Discussing some bizarre phenomena in astro and why does it occur.
- This is an interactive session where we would be putting ideas and briefly discuss them.
- Note that some problems are open ended and may not have an accepted solution
- If you already know the answer please don’t give away the solution and let others try.

PS:

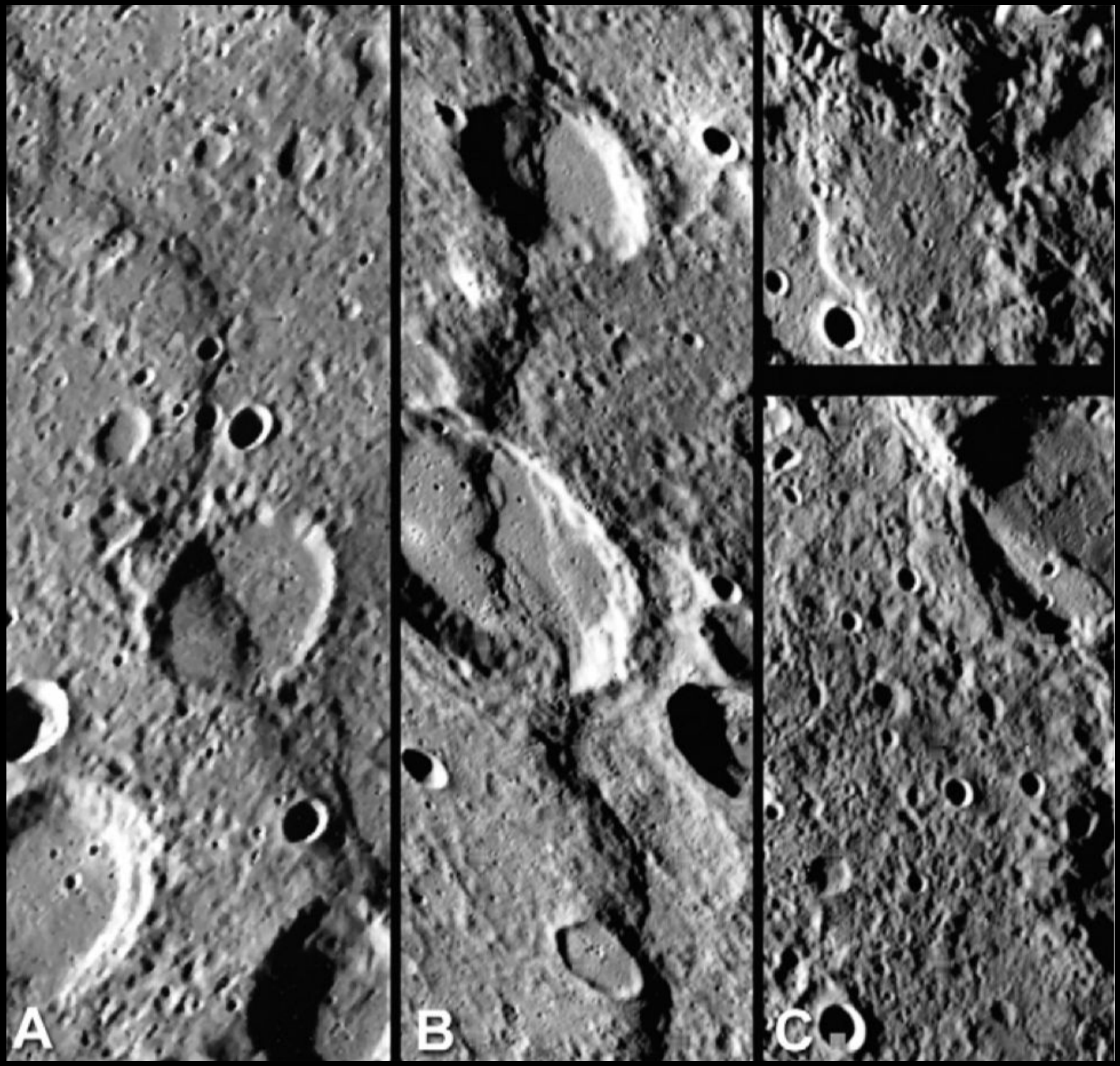
Prepared to be amazed.

PPS:

If you aren’t amazed then I would not have done a good job. Astro is still amazing.....

Planet Mercury

- Mercury is a very strange planet. But we will concentrate on a specific feature. Look closely in the upcoming images. What do you observe?



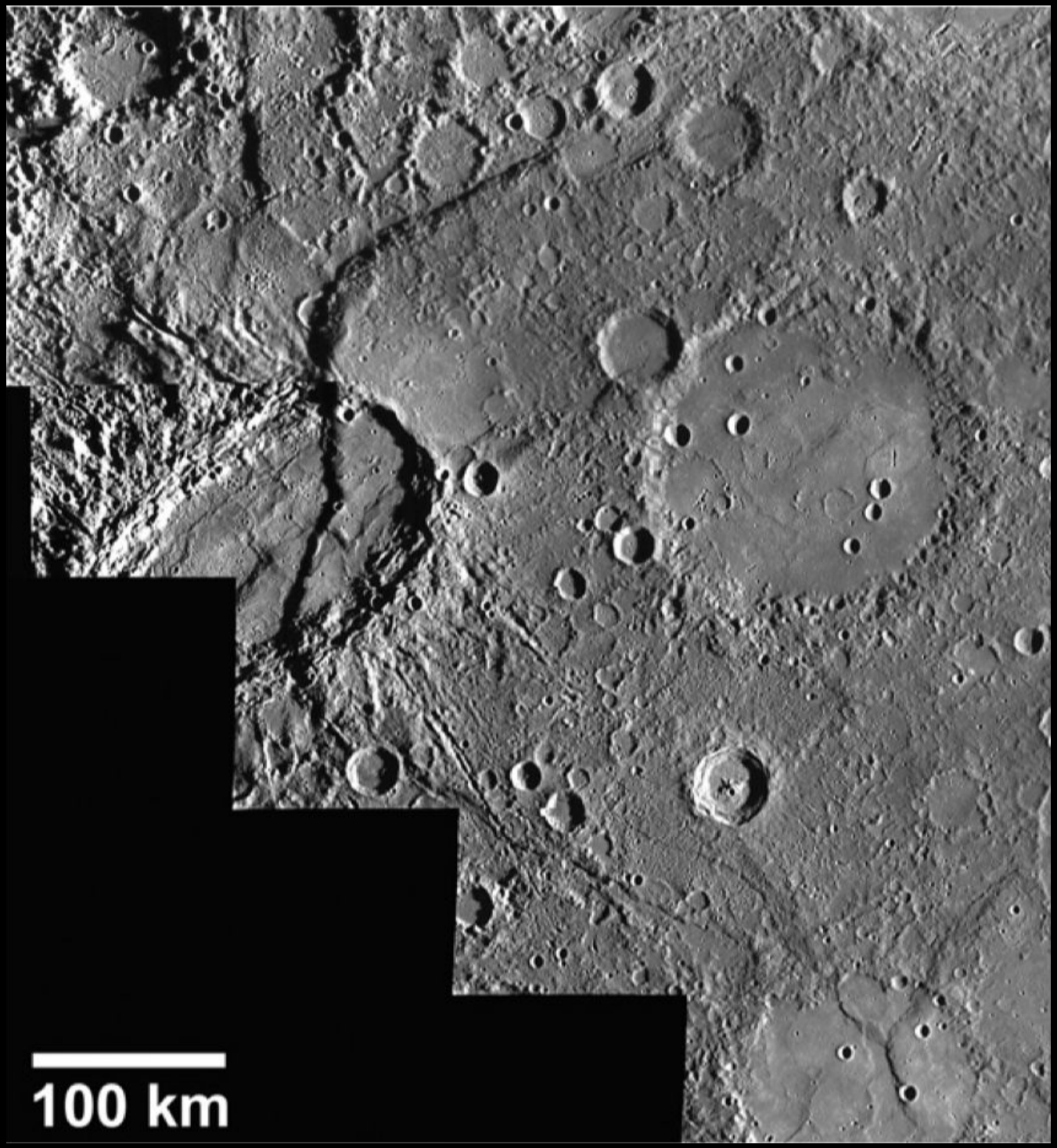
Craters!!!

Good…

But what else?

Maybe next image will help.

Source: “Tectonics of Mercury” by T. R. Watters and F. Nimmo



These are compression folds and landforms interpreted to be the surface expressions of thrust faults.

This feature implies that Mercury is shrinking.

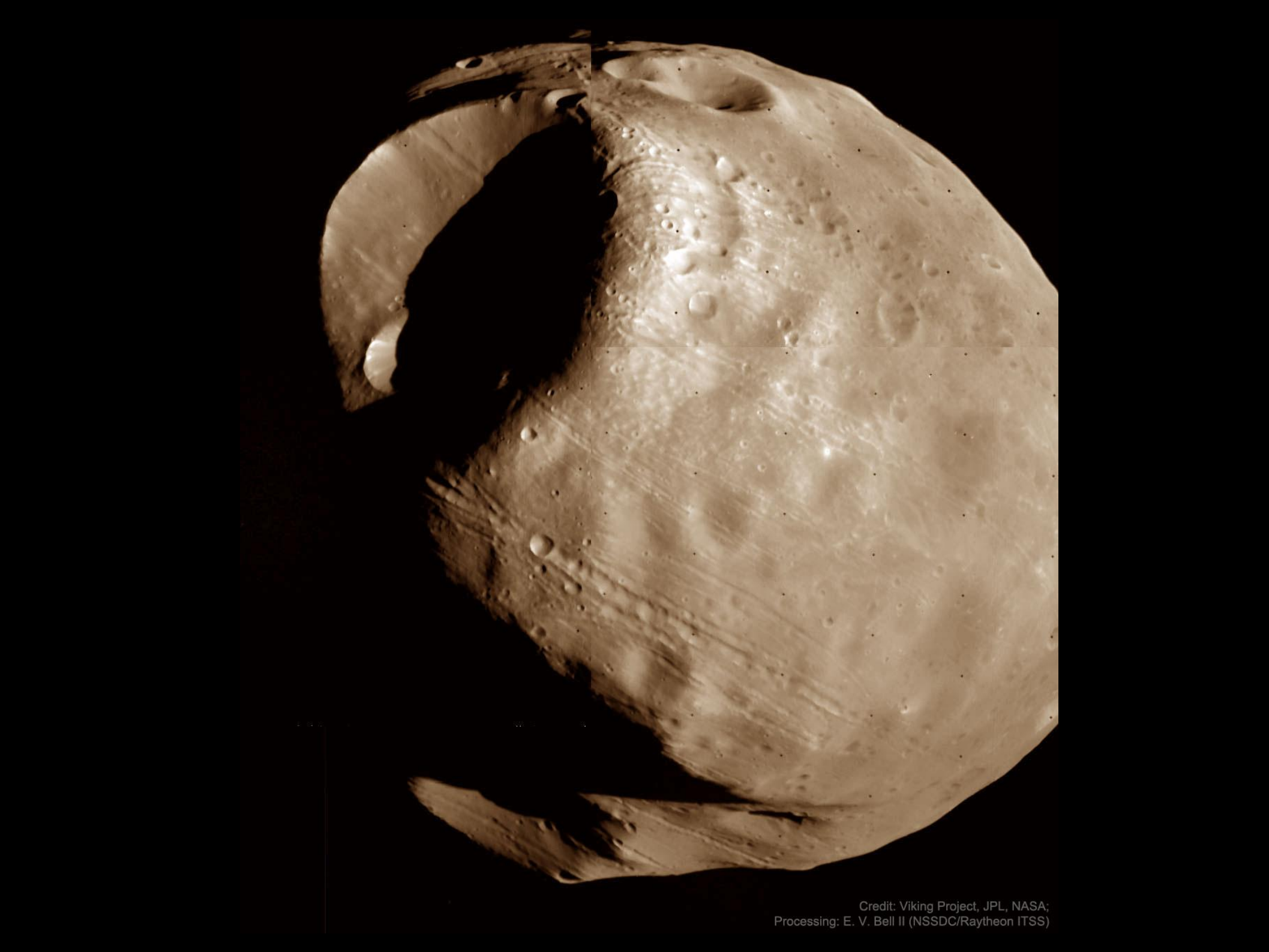
But why is it shrinking?

These features emerged as the interior of the planet has cooled. This cooling has led the planet to contract and deform.

Source: “Tectonics of Mercury” by T. R. Watters and F. Nimmo

Mars and its Moons

- Mars is even more peculiar than Mercury. And so are the moons orbiting this planet: Phobos (22.2km diameter) and Deimos (12.6km diameter). Once again we observe the surface features of an extraterrestrial body.



Credit: Viking Project, JPL, NASA;
Processing: E. V. Bell II (NSSDC/Raytheon ITSS)

- Theory 1: May have been from impact which caused the Stickney crater. Later they were found to be unrelated.
- Theory 2: Tidal forces due to Mars caused “stretch marks”. Unfortunately, Tidal forces found to be too weak.

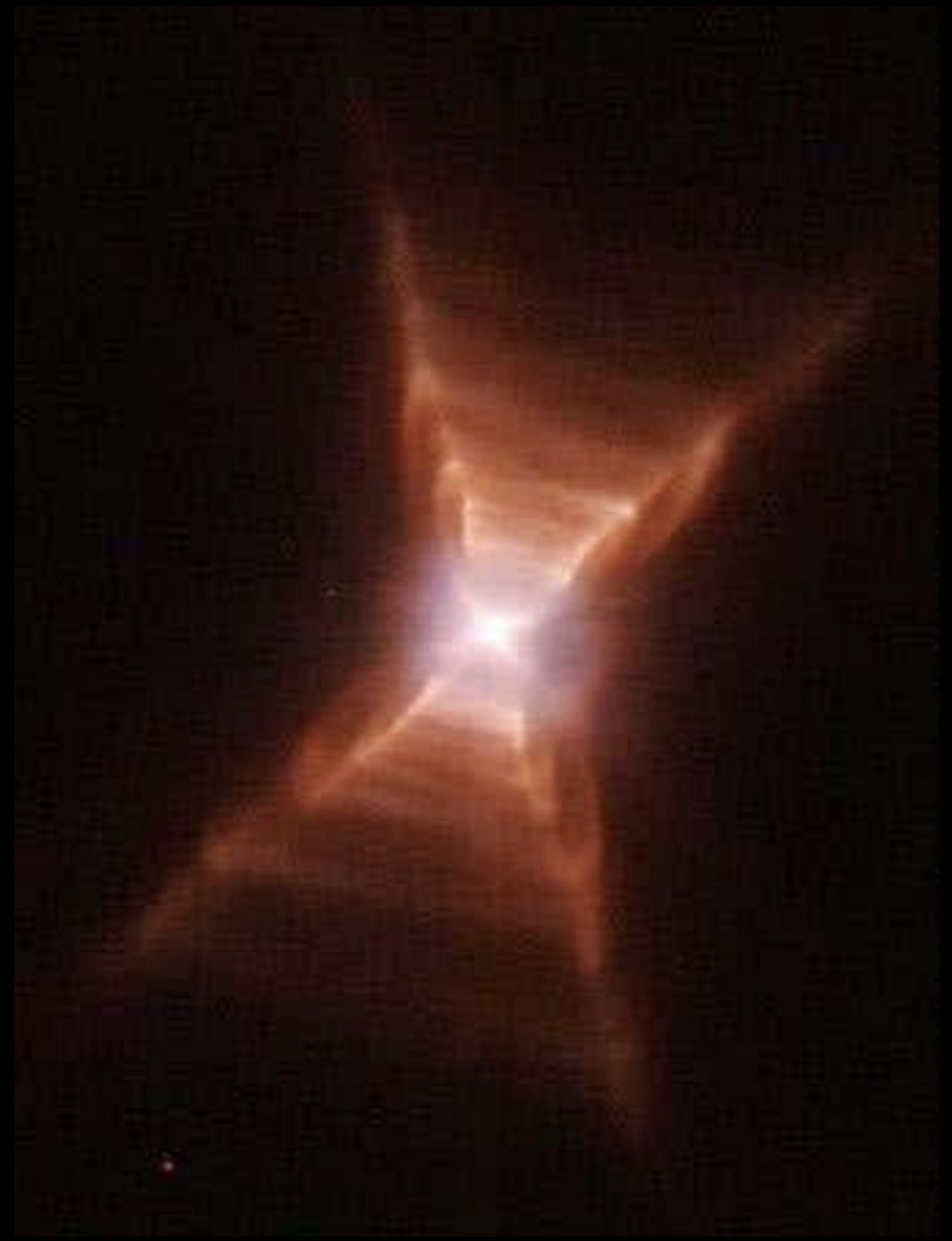
Notice that these grooves are not just grooves. They are more like a chain of craters

- Theory 3: Phobos was bombarded by rubble from Mars after explosive collision with some other mass. And due to orbital motion of Phobos, it formed a chain of craters. Unfortunately, there were regions where there were no craters that would have craters if above case was true.
- Craters could not have been formed from meteorite impacts on Phobos, because then they would have been radial had they not escaped Phobos and not parallel. ***Missed again ;(***
- Most recent Theory: What about shrapnel from meteorite impact on Phobos that escaped Phobos but not Mars. They would orbit Mars and could hit Phobos in a parallel arrangement. This theory is by Nayak and Asphaug.

Red Square Nebula

- A **nebula** is a giant cloud of dust and gas in space. Some nebulae (more than one nebula) come from the gas and dust thrown out by the explosion of a dying star, such as a supernova. Other nebulae are regions where new stars are beginning to form.

SOME NEBULAE SHAPES



Red Square Nebula.

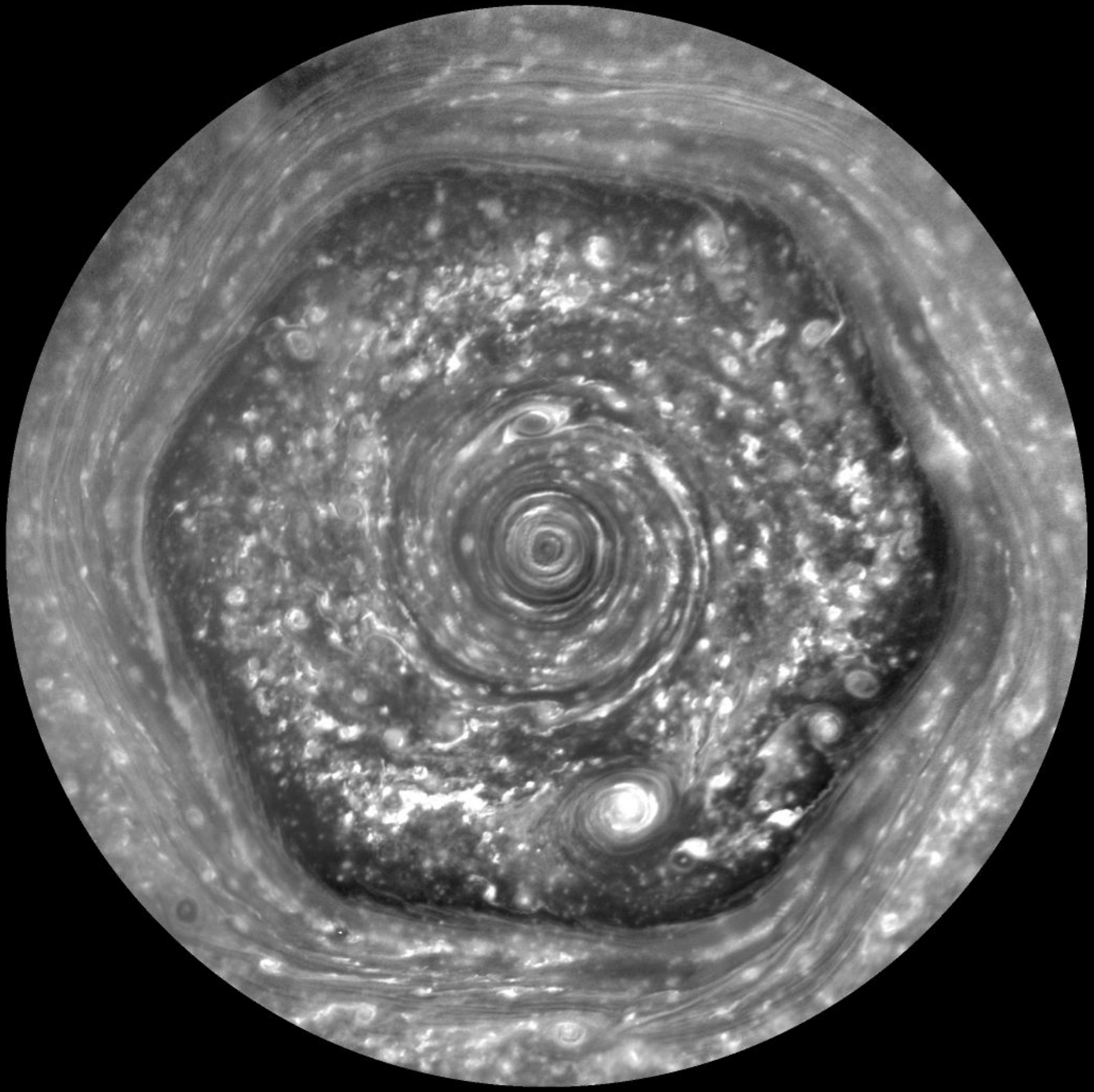
What could be the reason for such near perfect shape?

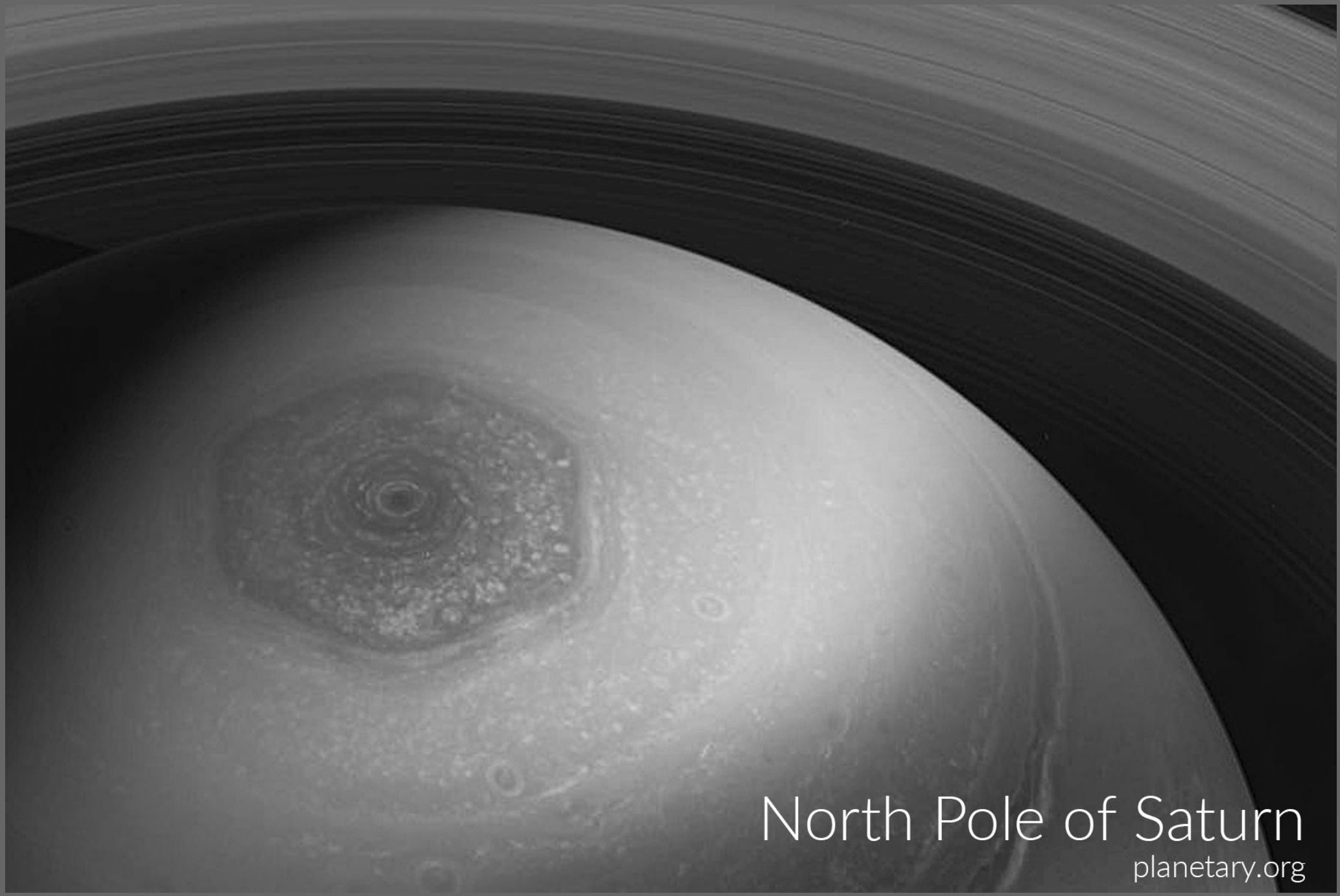
Explanation: Stellar Jets

The central star (possibly) ejects gas in the form of 2 cones that are exactly aligned 90 degrees to our field of view, thus form a rectilinear shape.

Note that this is very simplified explanation. It is much more complicated than that. But the point to take home is perspective of observation matters a lot in Astronomy.

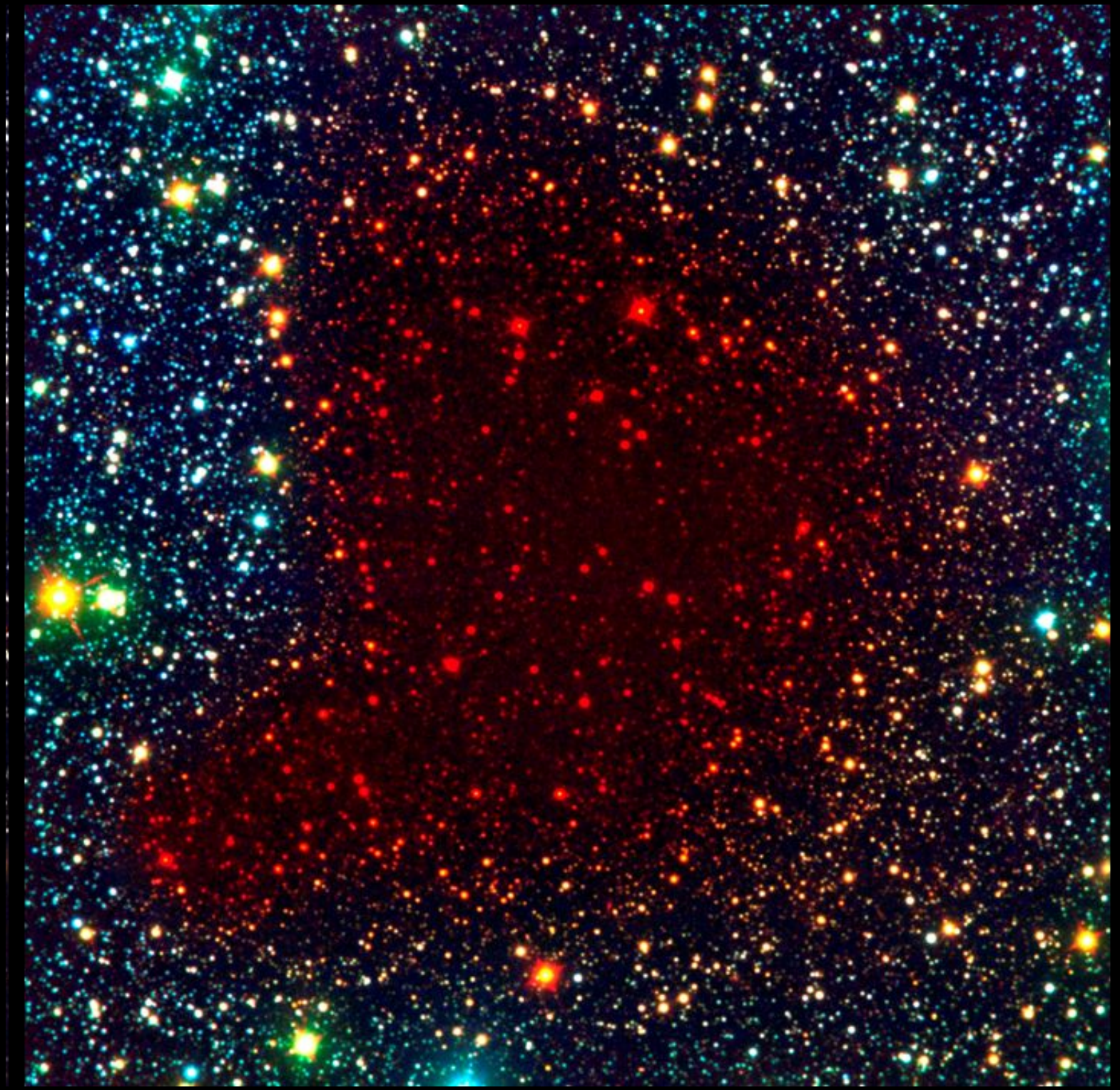
Some more symmetry

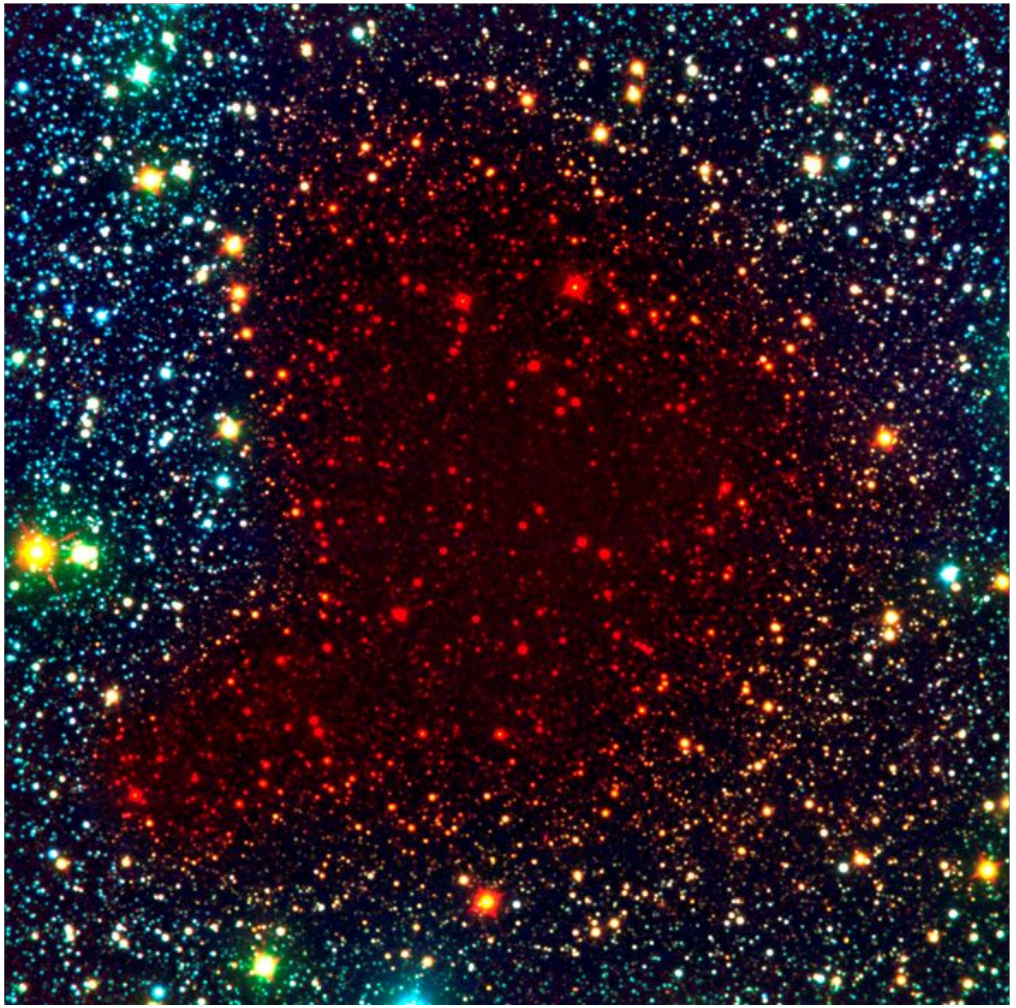




Some theories, but no rigid reason…..

Barnard 68

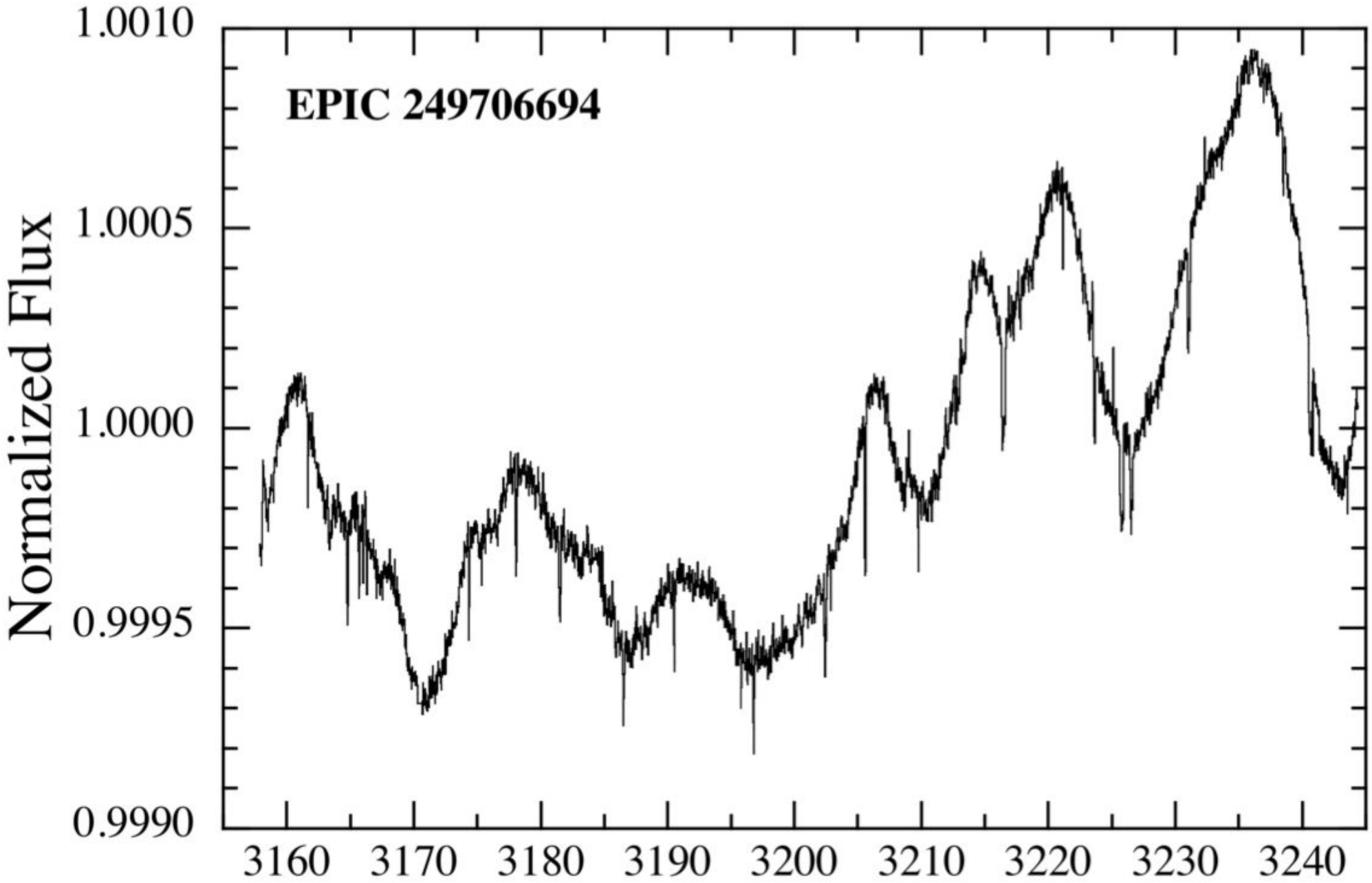




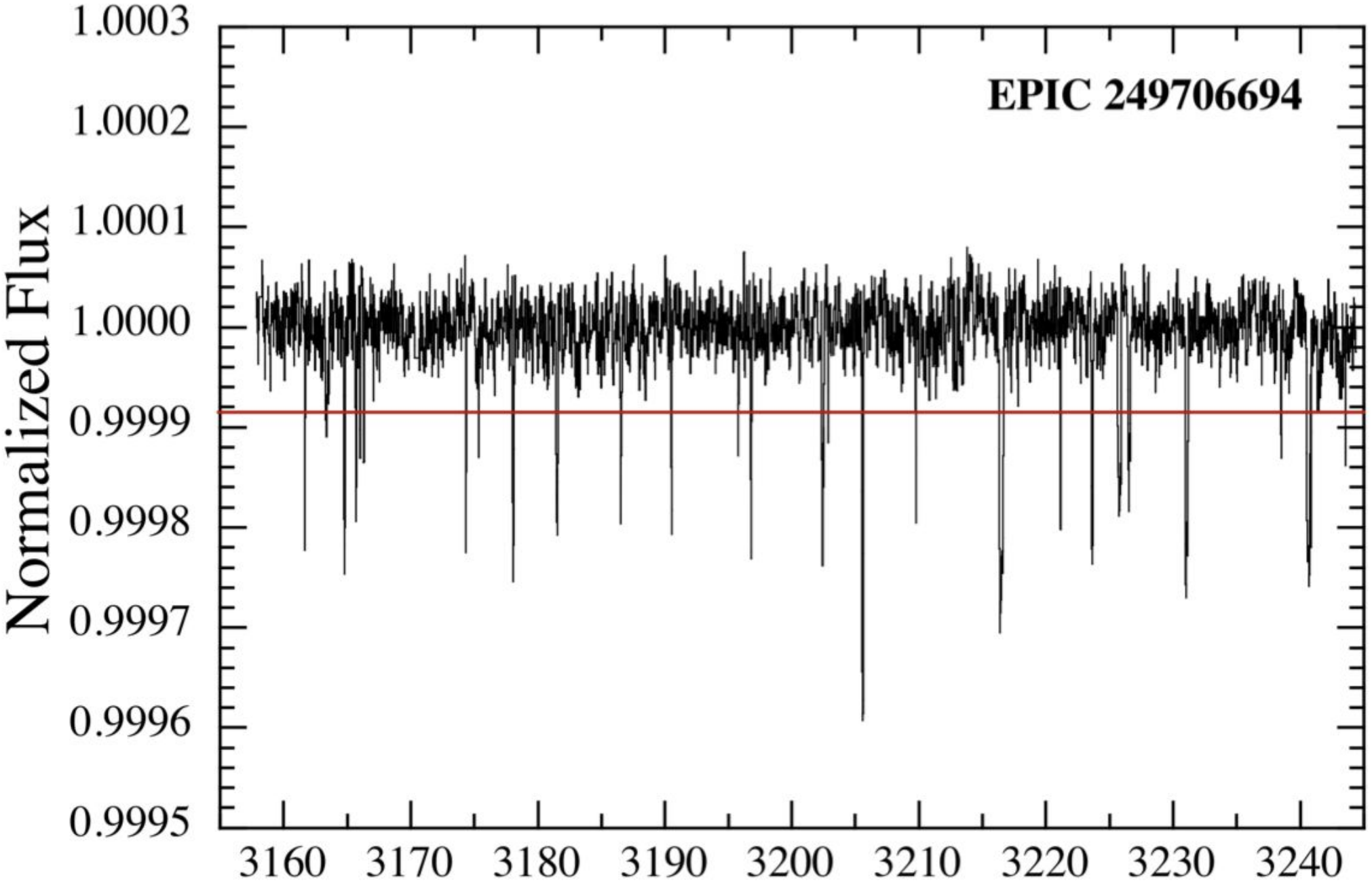
It is dark absorption nebula or Bok globule. Dark clouds are dark because they contain myriads of submicron-sized solid particles - the *interstellar dust grains* . They also harbour many different species of molecules. They are responsible for the obscuration of light at visible wavelengths. Despite being opaque at visible-light wavelengths, it can still be observed in lower wavelengths (infrared) and in fact it is not empty at all !!

Freaky Star

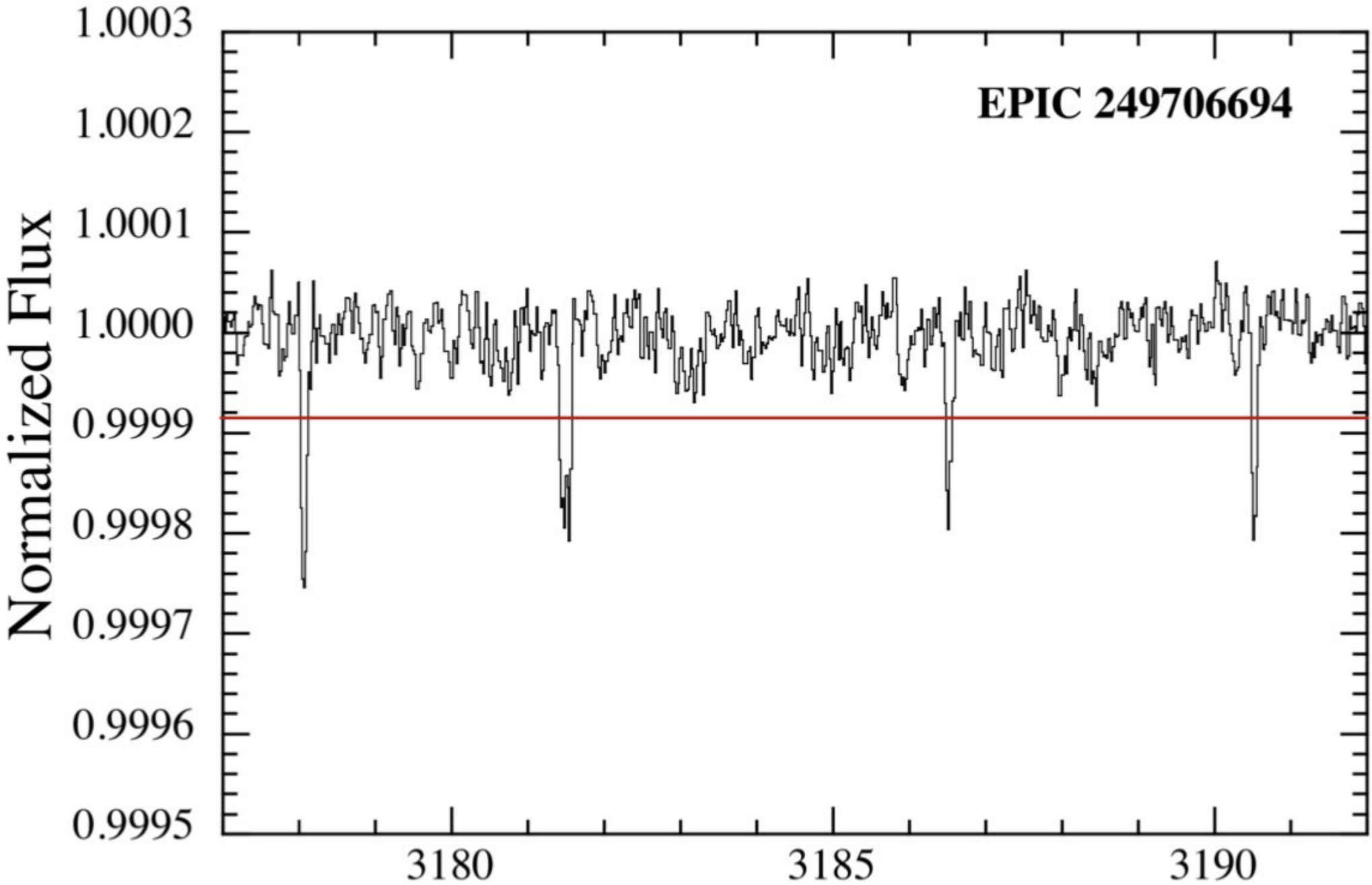
What are common causes of a reduction in a star’s received flux?



Source: https://arxiv.org/pdf/1906.11268.pdf



Source: https://arxiv.org/pdf/1906.11268.pdf



Source: https://arxiv.org/pdf/1906.11268.pdf

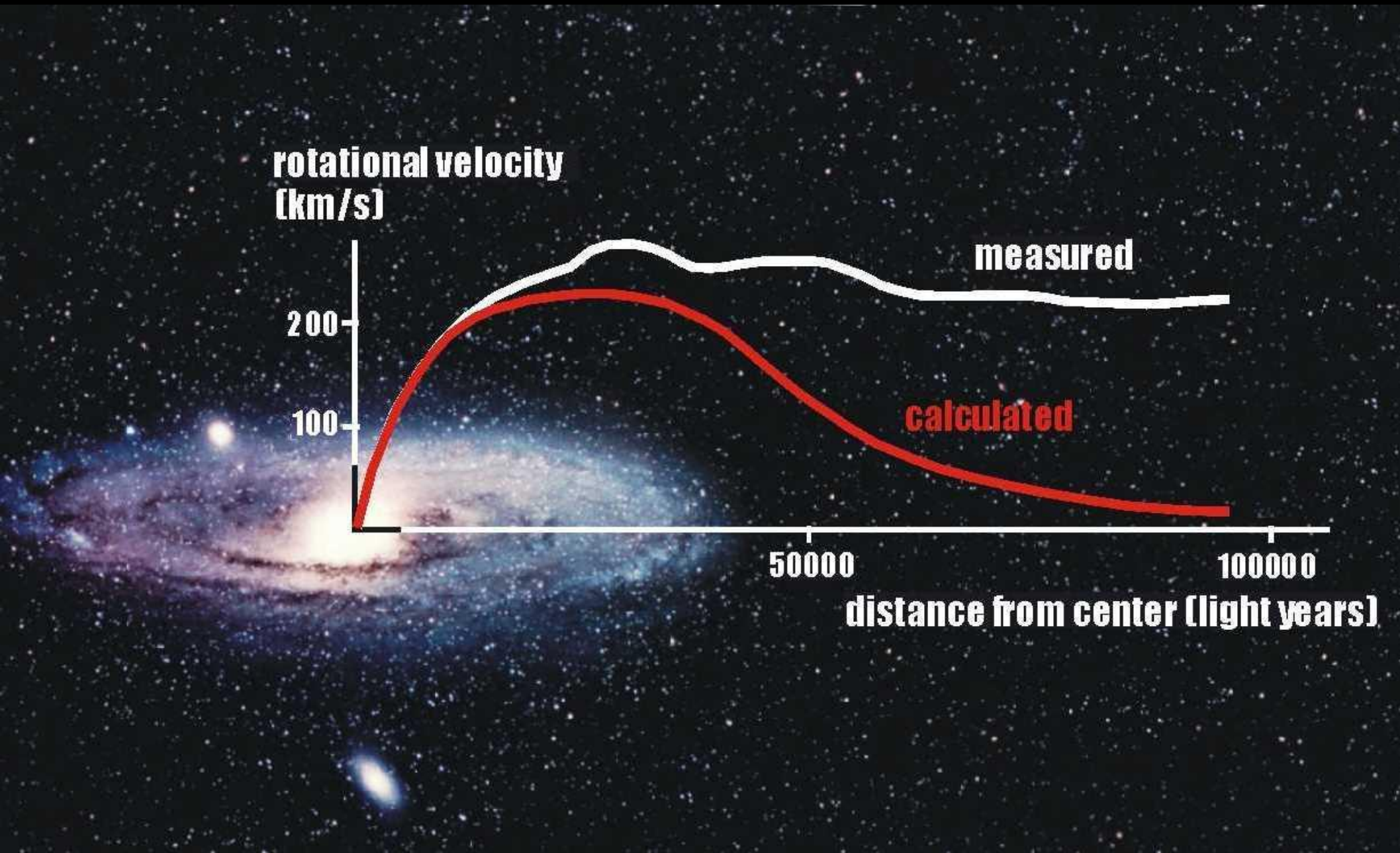
Freaky Star

1. Star is a variable star like Cepheid, RR Lyrae, etc.
2. Star is is being transited by another star/planet.
3. Star is a fast-rotating neutron star in which case it sends out pulses.

…...and many more reasons. But most of them are periodic or singular bursts.

But none of them could explain this unusual behaviour. We could try a combination of reasons, but that doesn't work out satisfactorily.

Galaxy Rotation Problem



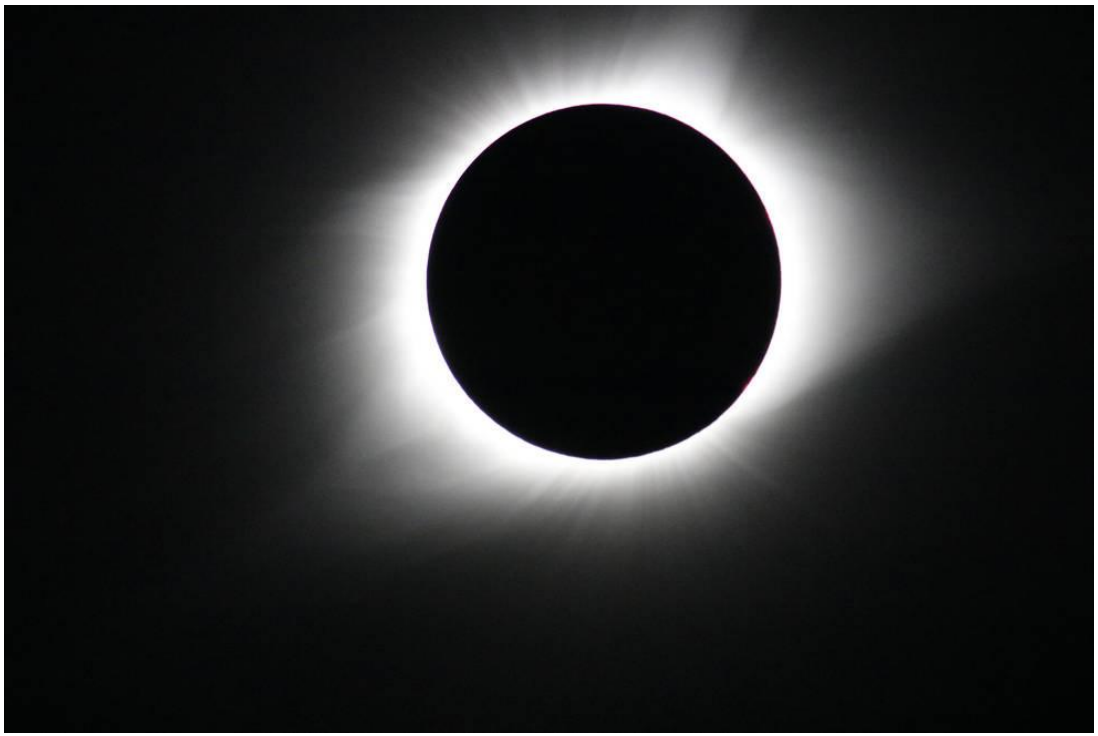
Sun’s Corona

During an 1869 total eclipse. Because different elements emit light at characteristic wavelengths, scientists can use spectrometers to analyze light from the Sun and identify its composition. But the green line observed in 1869 didn’t correspond to any known elements on Earth.

New element!!!!
Scientists thought perhaps they’d discovered a new element, and they called it coronium.

Not until 70 years later did a Swedish physicist discovered the element responsible for the emission is iron, superheated to the point that it's ionized 13 times, leaving it with just half the electrons of a normal atom of iron. And therein lies the problem: Scientists calculated that such high levels of ionization would require coronal temperatures around 2 million degrees Fahrenheit — nearly 200 times hotter than the surface.

Still unsolved….



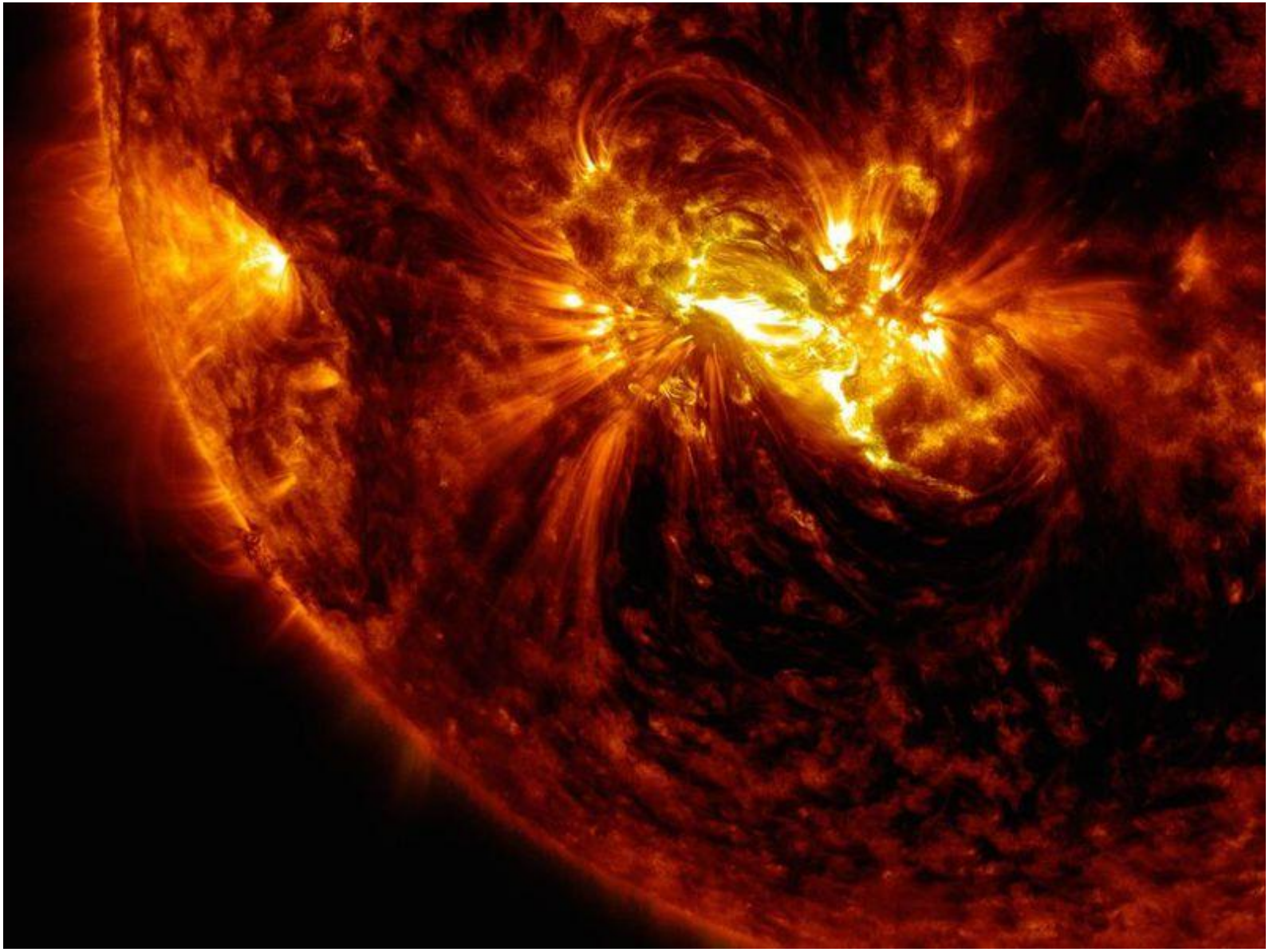
Detonating Sea Mines

“As part of Operation Pocket Money, the U.S. Navy planted a series of Destructor sea mines near strategic ports off the coast of North Vietnam. A few weeks later, on August 4, 1972, crew members aboard U.S. Task Force 77 aircraft suddenly observed a batch of explosions south of Hai Phong. In all, some 20 to 30 explosions were documented in just 30 seconds. Another 25 to 30 patches of muddy water were also observed, indicative of further explosions.”

Want a hint???

Many of those mines were “magnetic influence sea mines”

Want a hint???



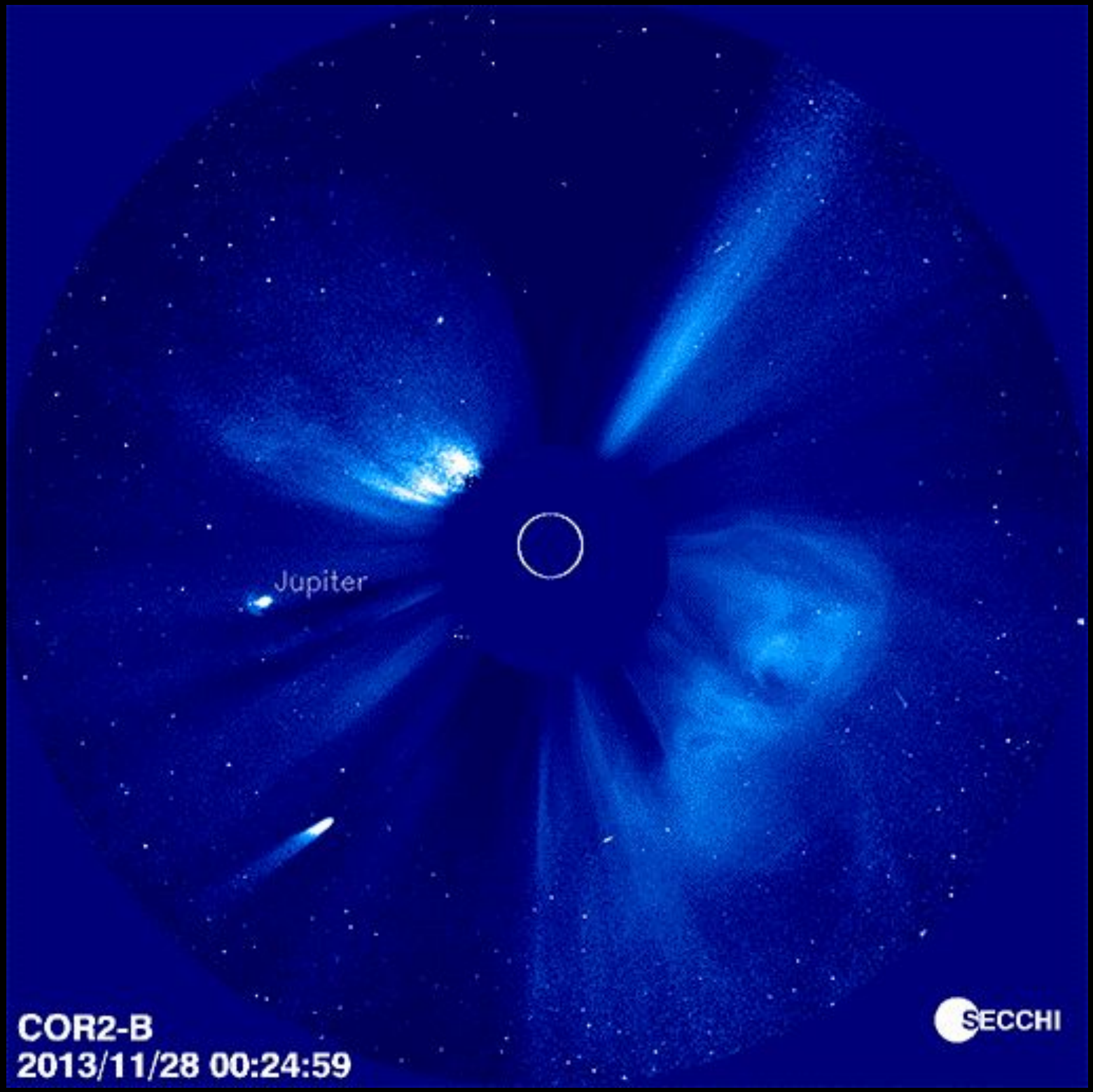
A mid-level solar flare captured by NASA's Solar Dynamics Observatory in 2017. (NASA/SDO)

Most feasible explanation

The mines that went off were “magnetic influence sea mines”, which detect the changes in magnetic field caused by passing ships. It known that solar activity can disrupt magnetic field on earth. Not only this between 4-5 August, 1972, many American and Canadian companies reported power disruptions and there were telephone and telegraph outages. Scientists in Philippines, Brazil and Japan also reported magnetic disruptions in the atmosphere.

Researchers say the event of 1972 was likely “Carrington-Class” which refers to a huge solar storm that took place in 1859…..

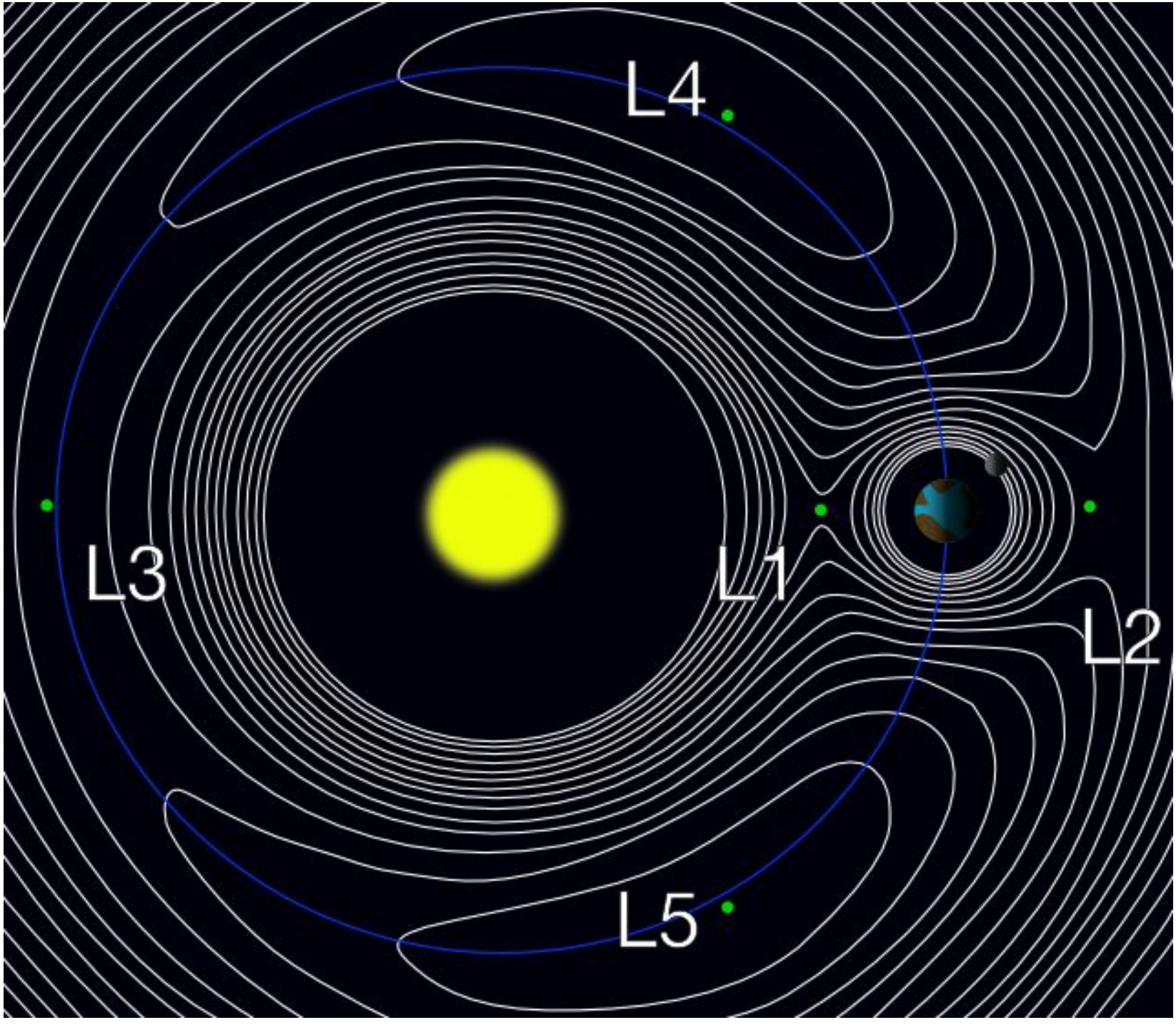
Just for Fun



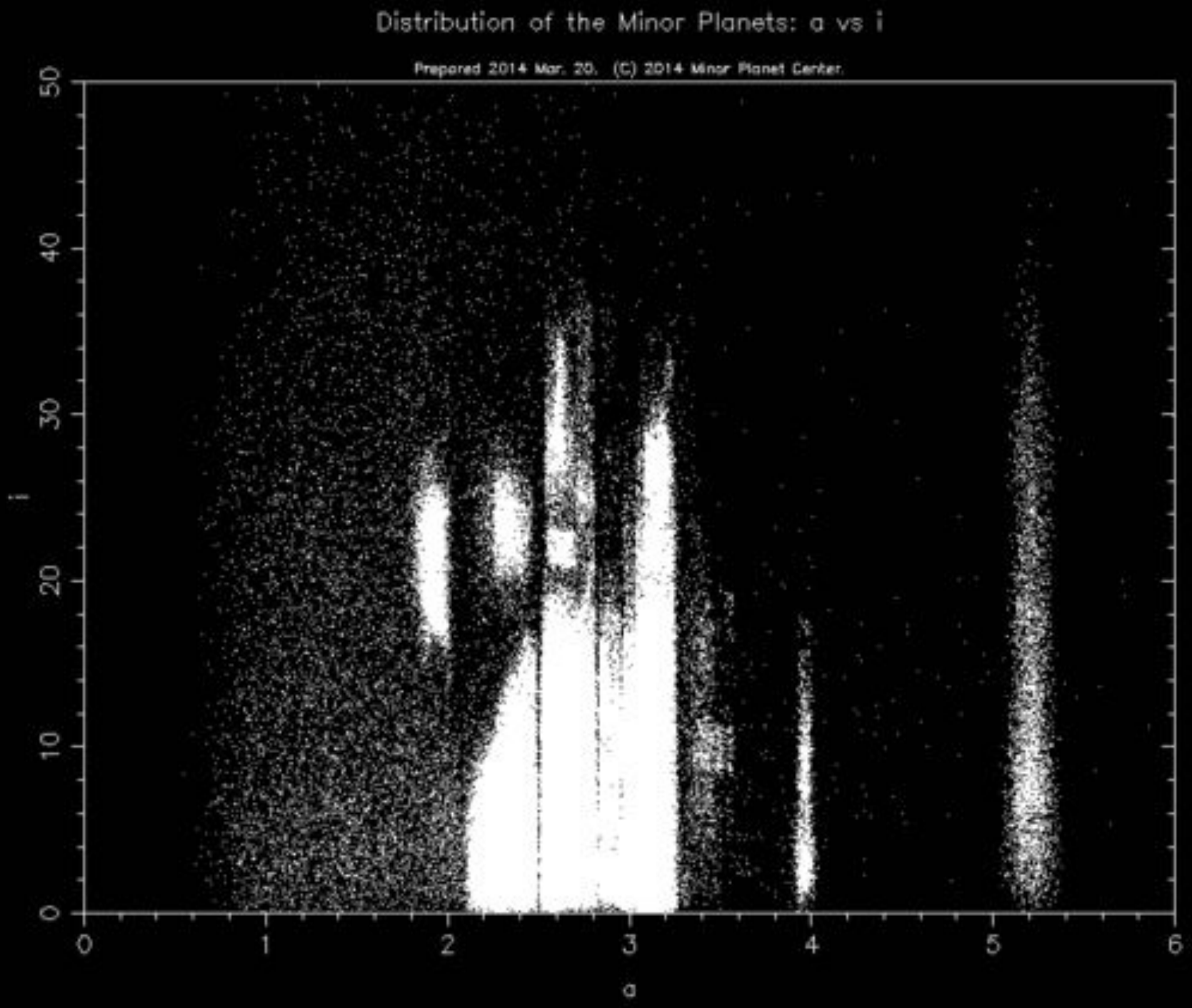
Comet ISON approaching sun.

The Solar and Heliospheric Observatory (SOHO)

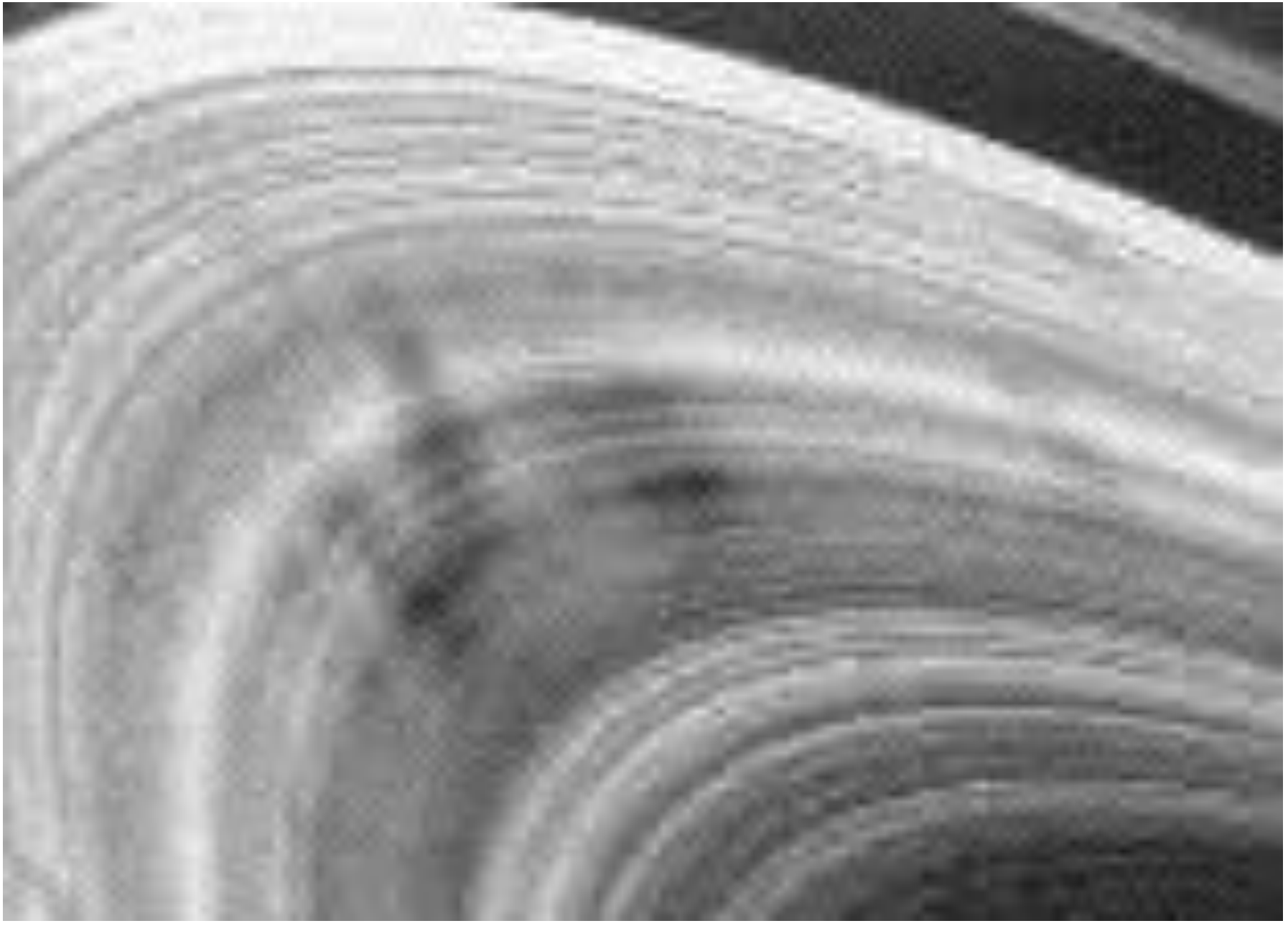
Lagrangian Points

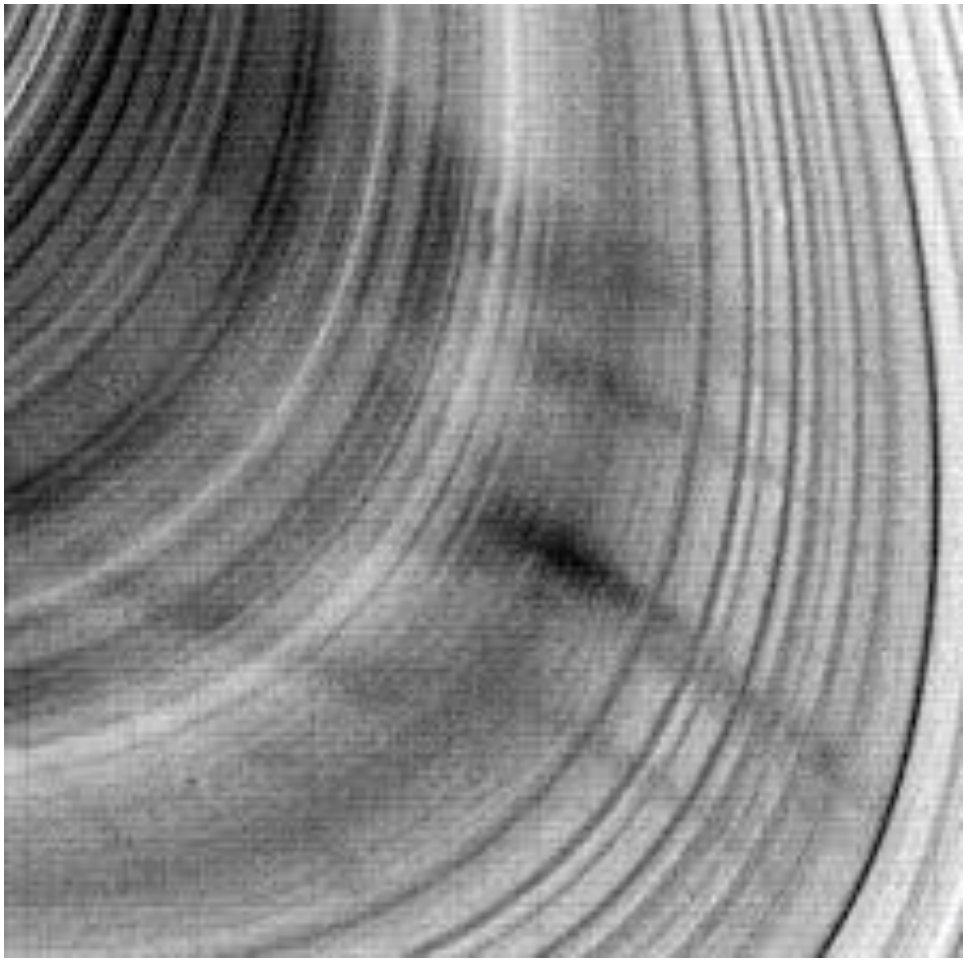


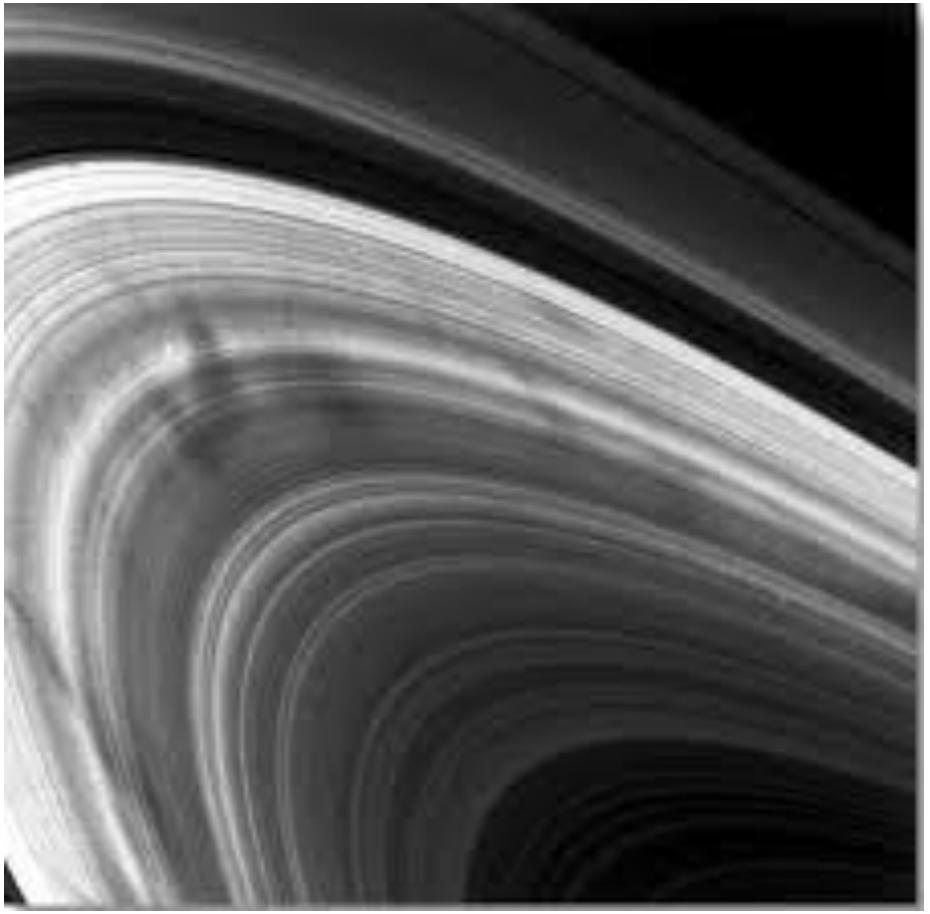
Gaps and Peaks in Asteroid Belt



Saturn’s Rings and some hideous spooks







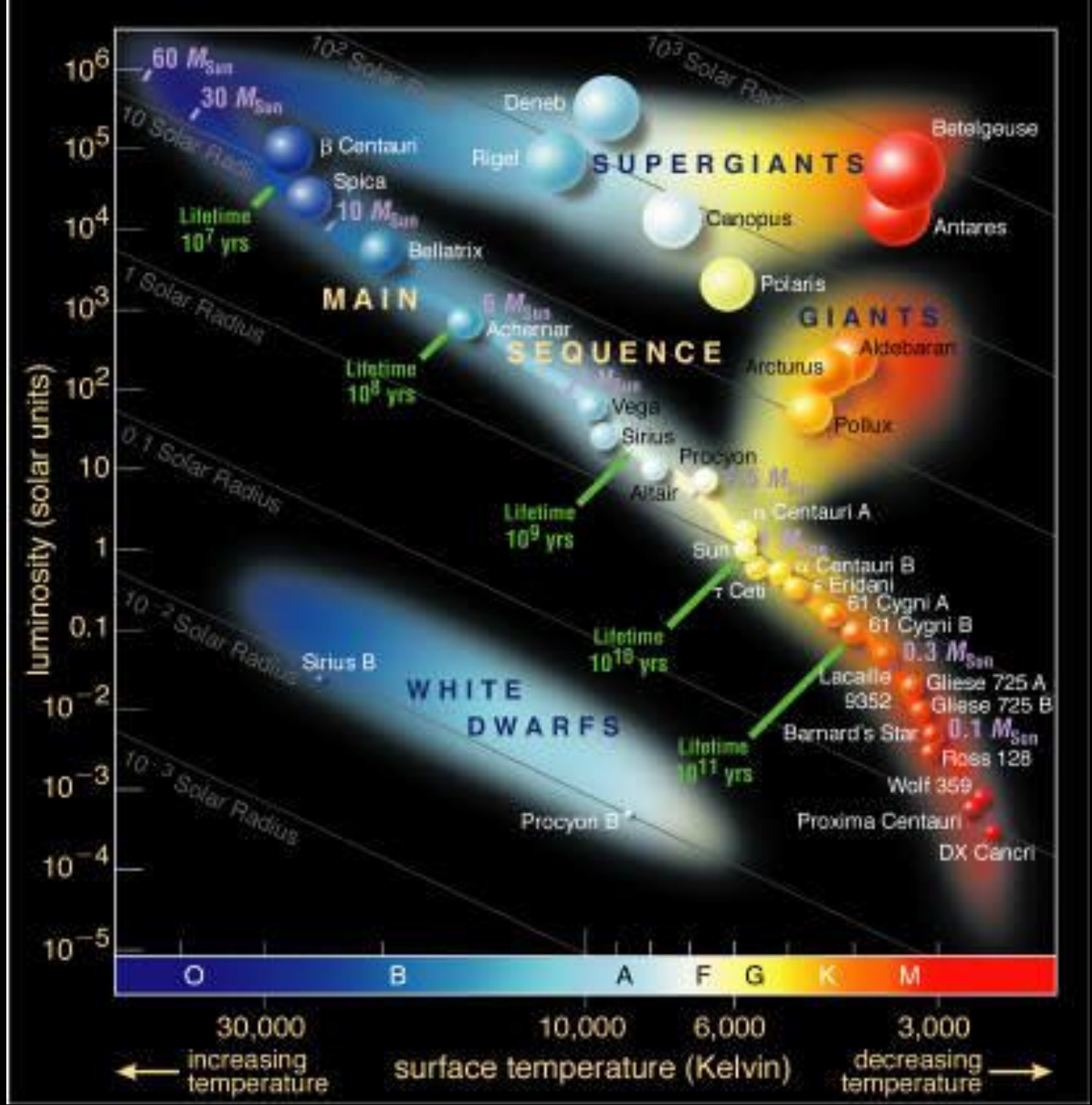
No one fully understands the reason these spokes exist, but the fact that they do NOT drift apart means they must be connected with the spin of Saturn and not with the motion of the many ring chunks.

Algol Paradox

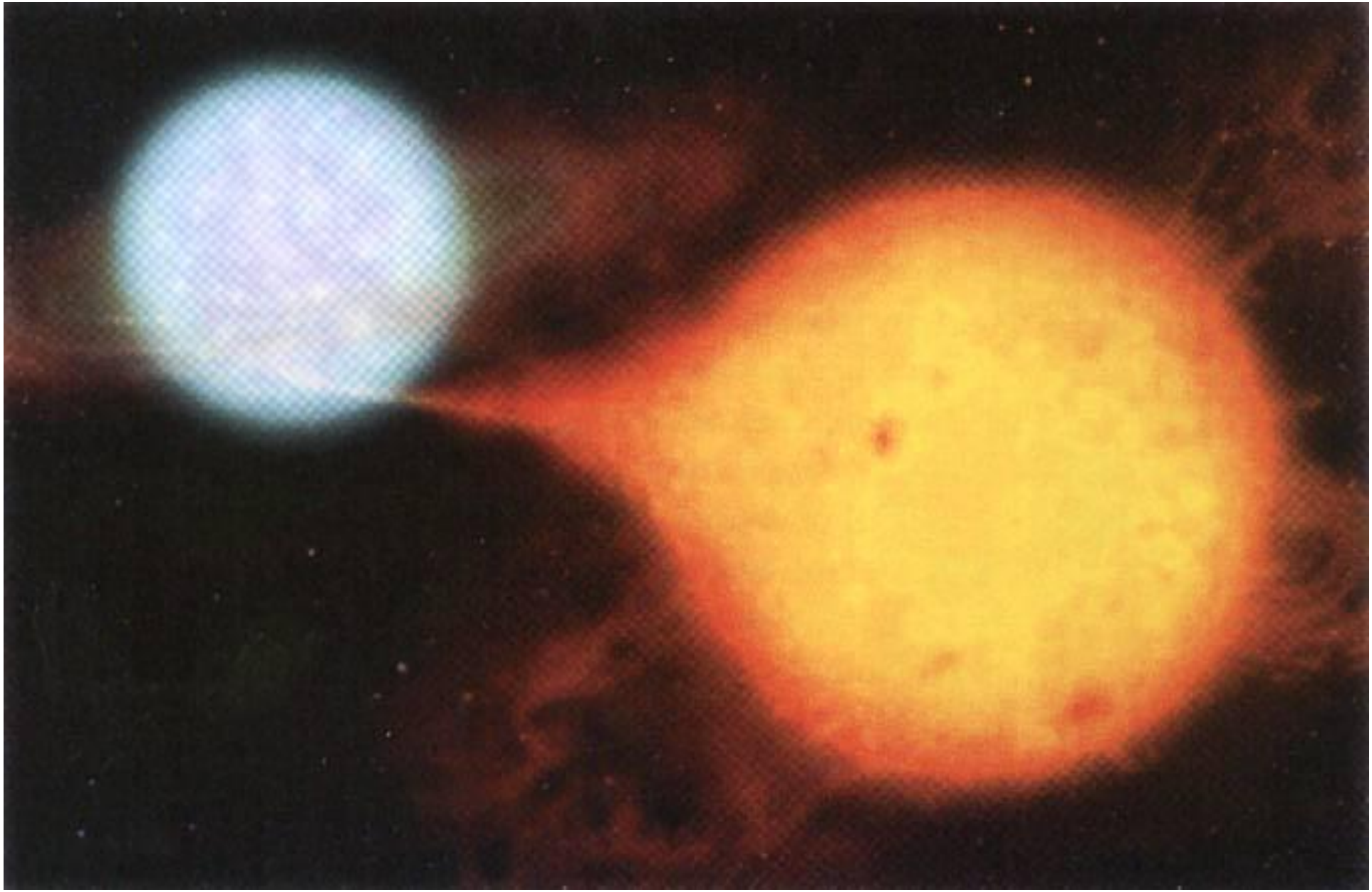
The well-known star Algol in Perseus is an eclipsing binary composed of a main-sequence star and a sub-giant. It was naturally assumed that the sub-giant, being the more evolved star, is also the more massive. It was found, however, that it is actually the less massive star.

According to Astrophysical equations, it is known that the star having higher mass spends less time in existence. That is it follows the “star cycle” faster than a less massive star.

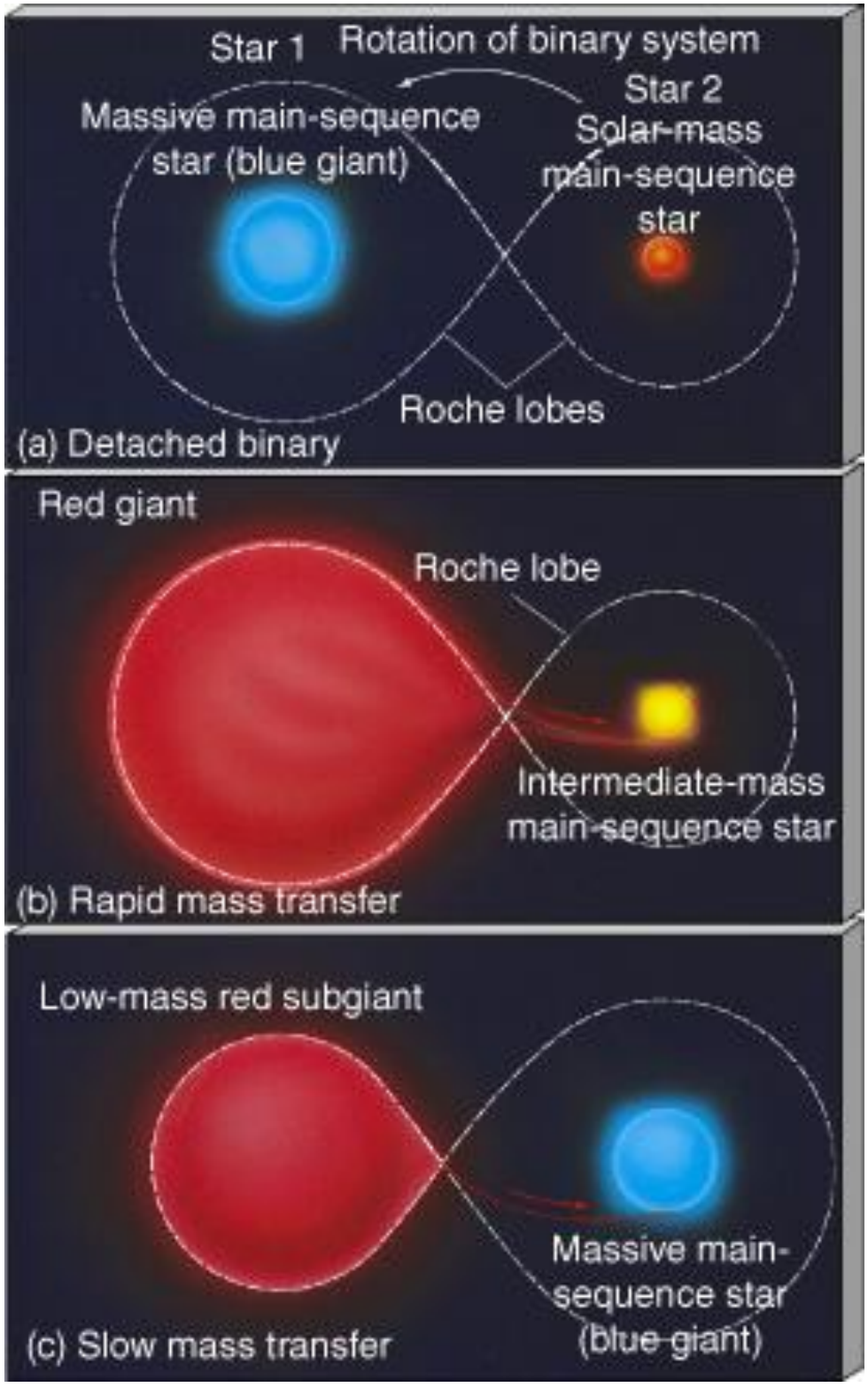
But this paradox posed a serious problem? How is older star less massive? Were they not formed at the same time????


luminosity (solar units)
10^6
10^5
10^4
10^3
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
60 M_{Sun}
30 M_{Sun}
10 M_{Sun}
6 M_{Sun}
10 Solar Radius
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
10^{-3} Solar Radius
10^2 Solar Radius
10^3 Solar Radius
Deneb
Rigel
Betelgeuse
SUPERGIANTS
β Centauri
Spica
Lifetime 10^7 yrs
Bellatrix
Canopus
Antares
Polaris
MAIN
SEQUENCE
GIANTS
Achernar
Lifetime 10^8 yrs
Aldebaran
Arcturus
Vega
Pollux
Sirius
Procyon
Altair
Lifetime 10^9 yrs
α Centauri A
Sun
α Centauri B
ε Eridani
τ Ceti
61 Cygni A
61 Cygni B
0.3 M_{Sun}
Lifetime 10^{10} yrs
Sirius B
WHITE
DWARFS
Lacaille 9352
Gliese 725 A
Gliese 725 B
Barnard's Star
0.1 M_{Sun}
Ross 128
Lifetime 10^{11} yrs
Wolf 359
Proxima Centauri
Procyon B
DX Cancri
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature

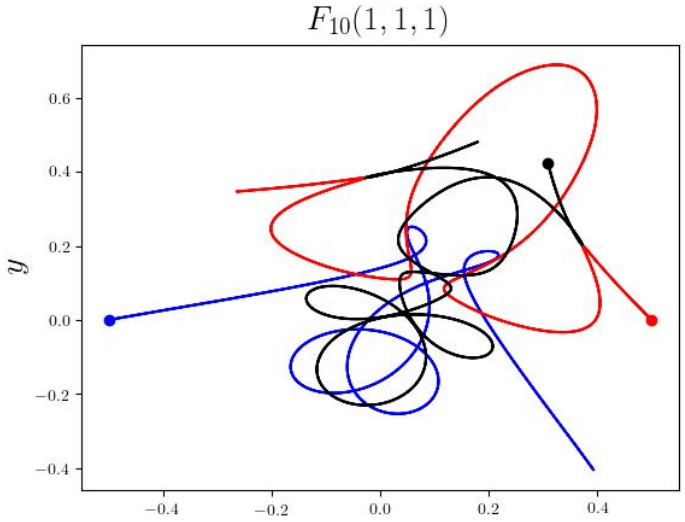
Hint……

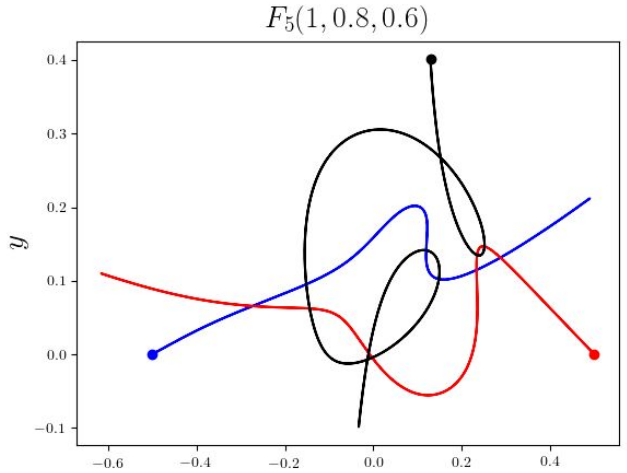


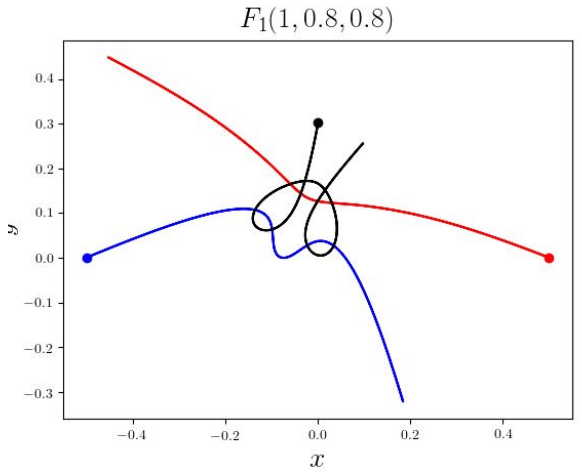
Accretion

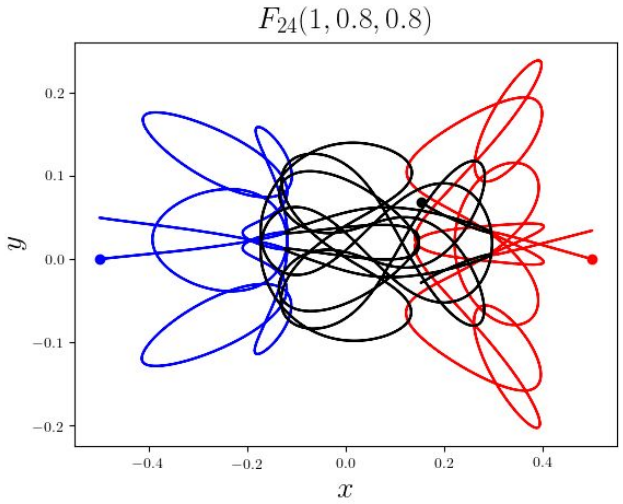

Star 1
Rotation of binary system
Star 2
Massive main-sequence star (blue giant)
Solar-mass main-sequence star
Roche lobes
(a) Detached binary
Red giant
Roche lobe
Intermediate-mass main-sequence star
(b) Rapid mass transfer
Low-mass red subgiant
Massive main-sequence star (blue giant)
(c) Slow mass transfer

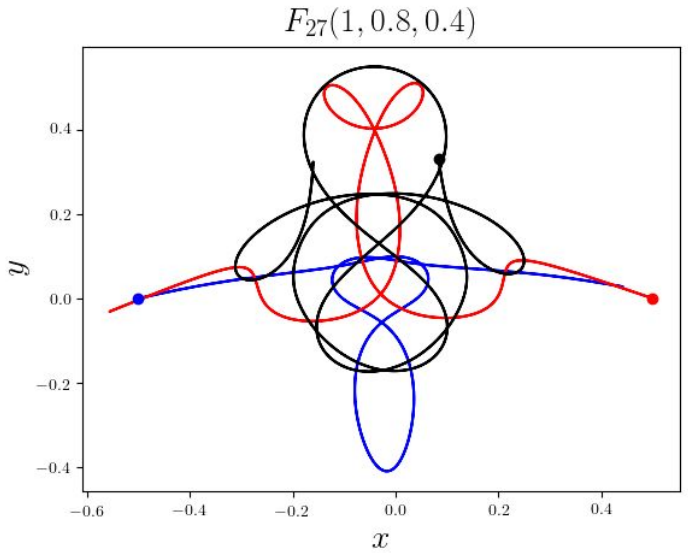
What is happening here!!

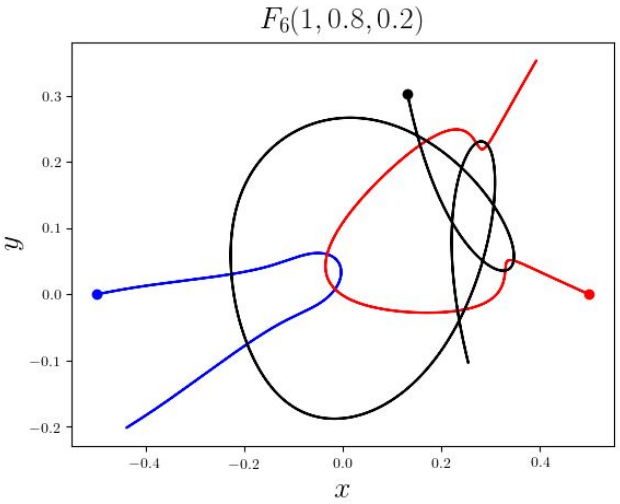










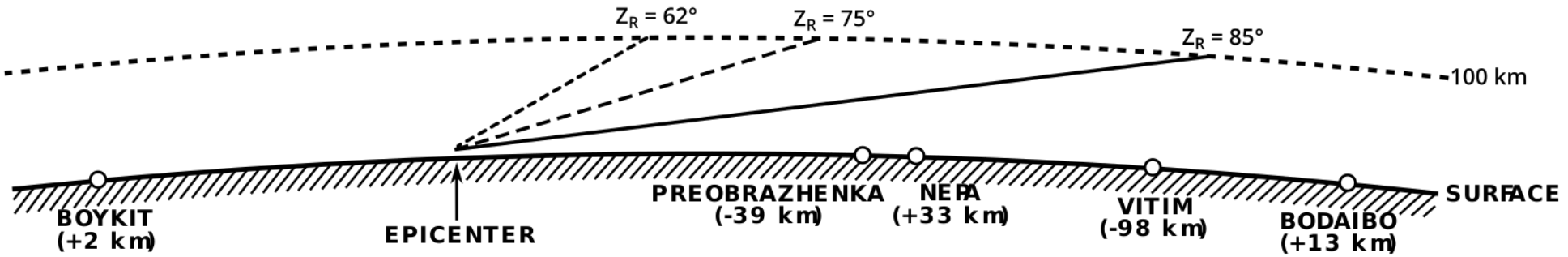


Source: **Periodic orbits for Newtonian planar three-body problem,** *Xiaoming LI and Shijun LIAO*

The Tunguska Enigma

Tunguska event, enormous explosion that is estimated to have occurred at 7:14 AM plus or minus one minute on June 30, 1908, at an altitude of 5–10 km (15,000–30,000 feet), flattening some 2,000 square km (500,000 acres) and charring more than 100 square km of pine forest near the Podkamennaya Tunguska River in central Siberia (60°55′ N 101°57′ E), Russia.

On the basis of historical records of significant noctilucent cloud(rare cloud form, probably composed of ice crystals and dust from meteor smoke, that occurs at a higher altitude than any other cloud form (about 82 km)) development in the skies over Europe following the event, some scientists contend that a comet caused the explosion.



In 1983, astronomer Zdeněk Sekanina published a paper criticising the comet hypothesis. He pointed out that a body composed of cometary material, travelling through the atmosphere along such a shallow trajectory, ought to have disintegrated, whereas the Tunguska body apparently remained intact into the lower atmosphere. Sekanina argued that the evidence pointed to a dense, rocky object, probably of asteroidal origin.

The chief difficulty in the asteroid hypothesis is that a stony object should have produced a large crater where it struck the ground, but no such crater has been found. It has been hypothesised that the passage of the asteroid through the atmosphere caused pressures and temperatures to build up to a point where the asteroid abruptly disintegrated in a huge explosion. The destruction would have to have been so complete that no remnants of substantial size survived, and the material scattered into the upper atmosphere during the explosion would have caused the skyglows.


Stay
Curious