SPACE IS FULL

By Chris R. Gilly

My name is Chris Gilly!

(Chris R. Gilly in publication)

Georgia Tech Physics College of Sciences

DramaTech Theater

ASTR 1000 – The Solar System – Summer A Session 2018

Instructor: Gilly (Chris Gilbert)
E-mail: Chris.Gilbert@colorado.edu
Class Website: learn.colorado.edu
Instructor Website: www.chrisgilbert.space
Class Meeting Time: Weekdays 11am - 12:35
Classroom: Duane G131
Instructor's Office: Duane D142
Office Hours: TBD, and by appointment

Goals for this class:

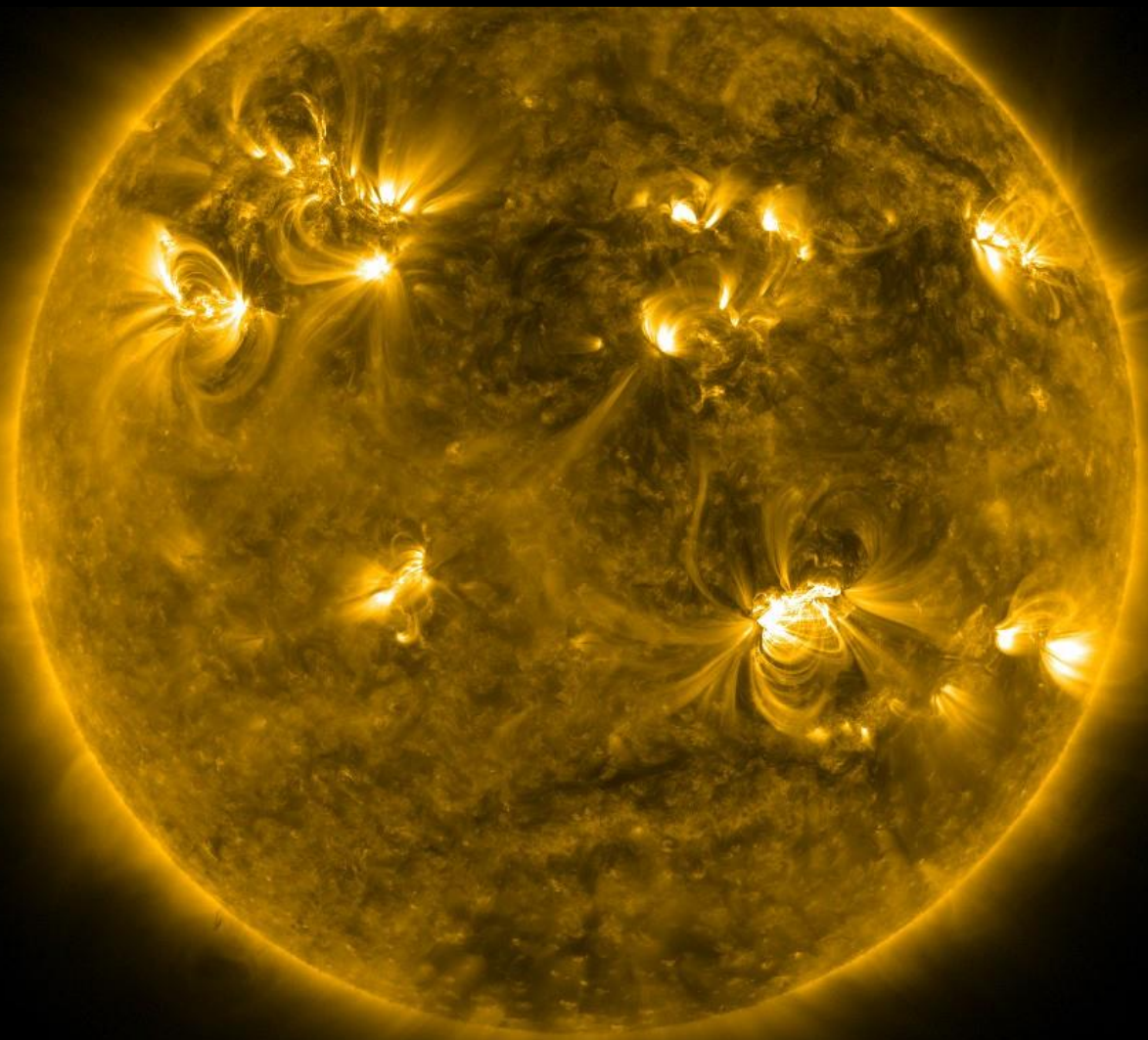
1. Instill the idea that *we are all scientists*
2. Instill an appreciation of the many ways in which science influences our everyday lives
3. Convey a sense of excitement associated with scientific discovery
4. Demonstrate that science naturally evolves to explain "how" (**not** "what")
5. Illustrate that a few scientific concepts explain many diverse phenomena
6. Encourage use of the scientific method to determine 'best explanations' for observed phenomena
7. Leave students with an understanding of the workings of the universe in which they live

Stuff I'm Doing:

Graduate Research Assistant/ PhD Candidate
Graduate Admissions Committee
Planetarium Series Coordinator
Boulder Jr Astronauts
Summer Instructor

Laboratory for Atmospheric and Space Physics

Astrophysical & Planetary Sciences
UNIVERSITY OF COLORADO **BOULDER**



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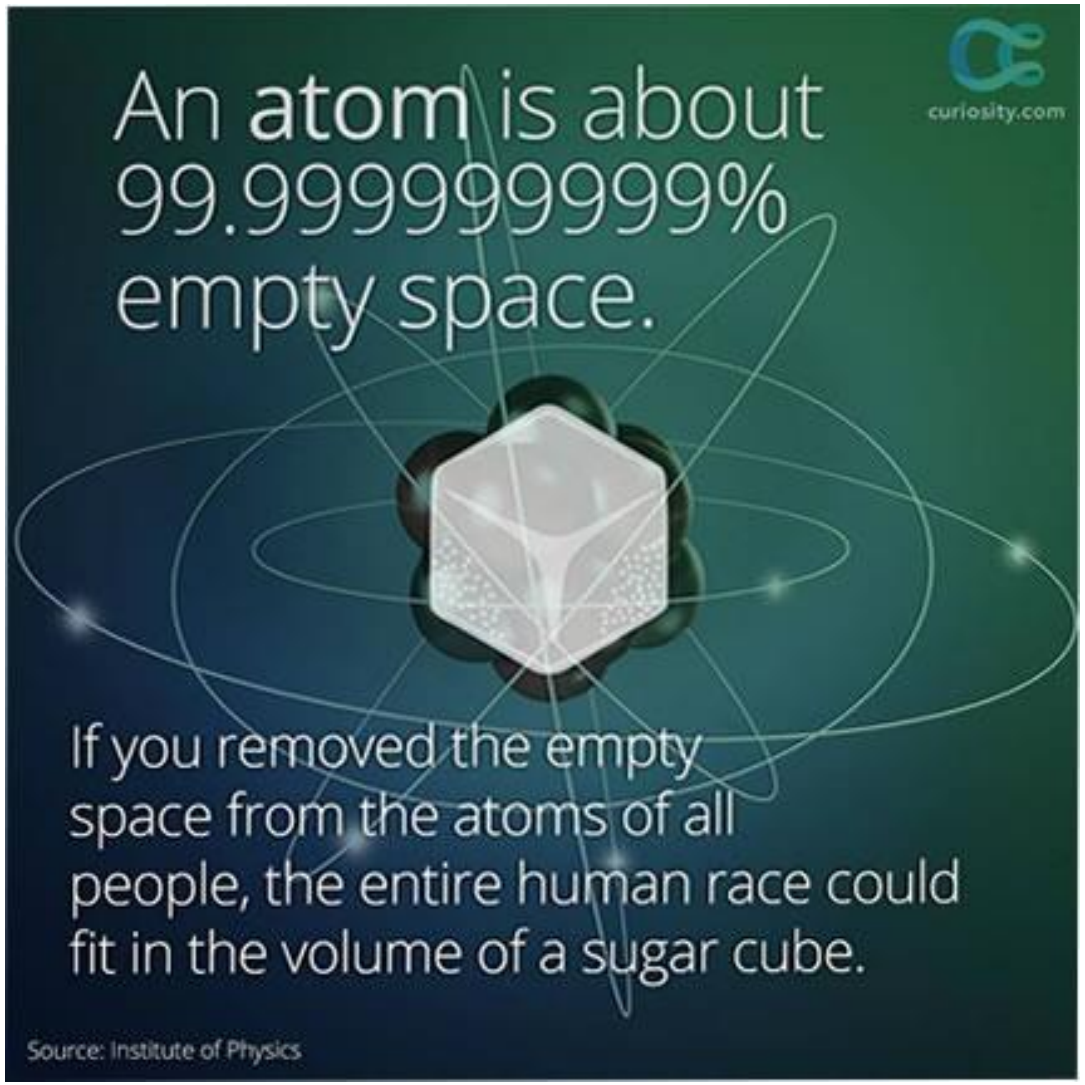
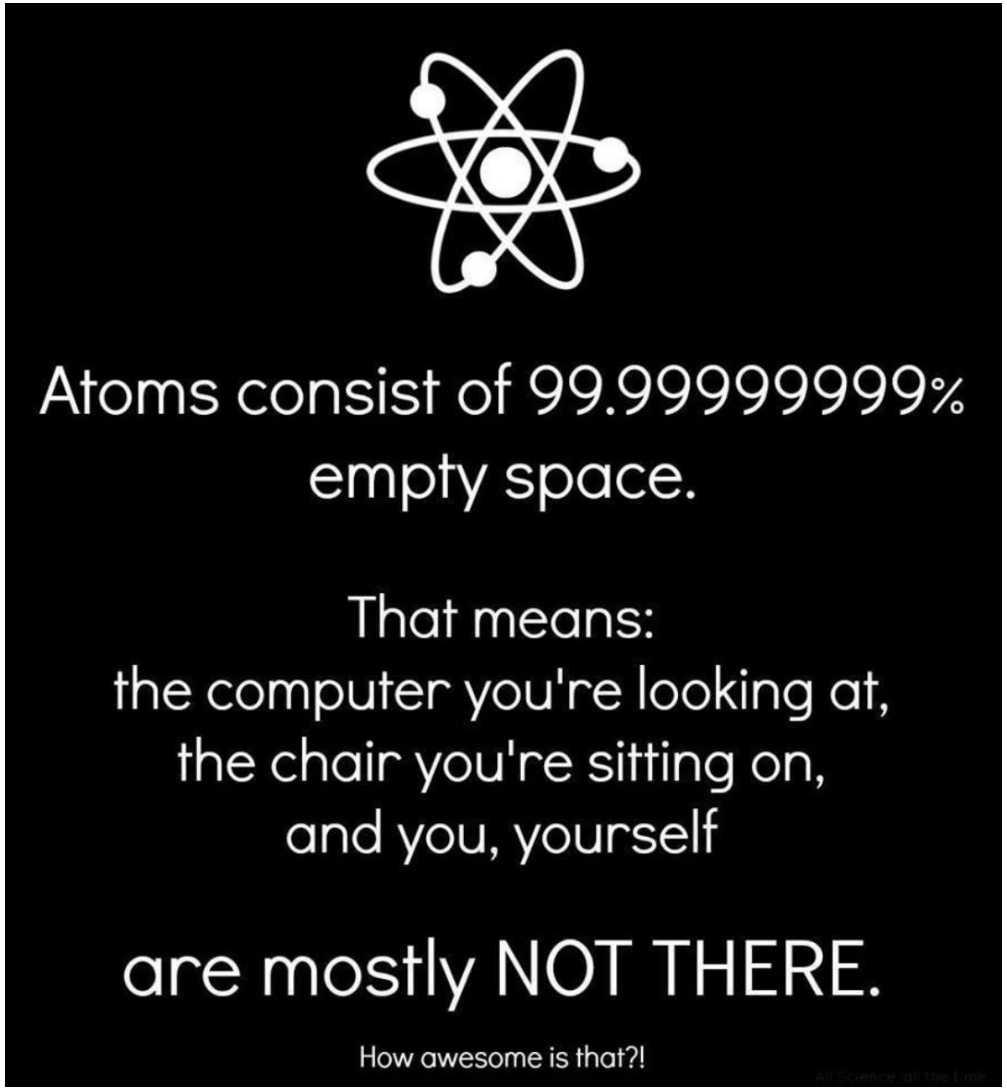
Check out my website!

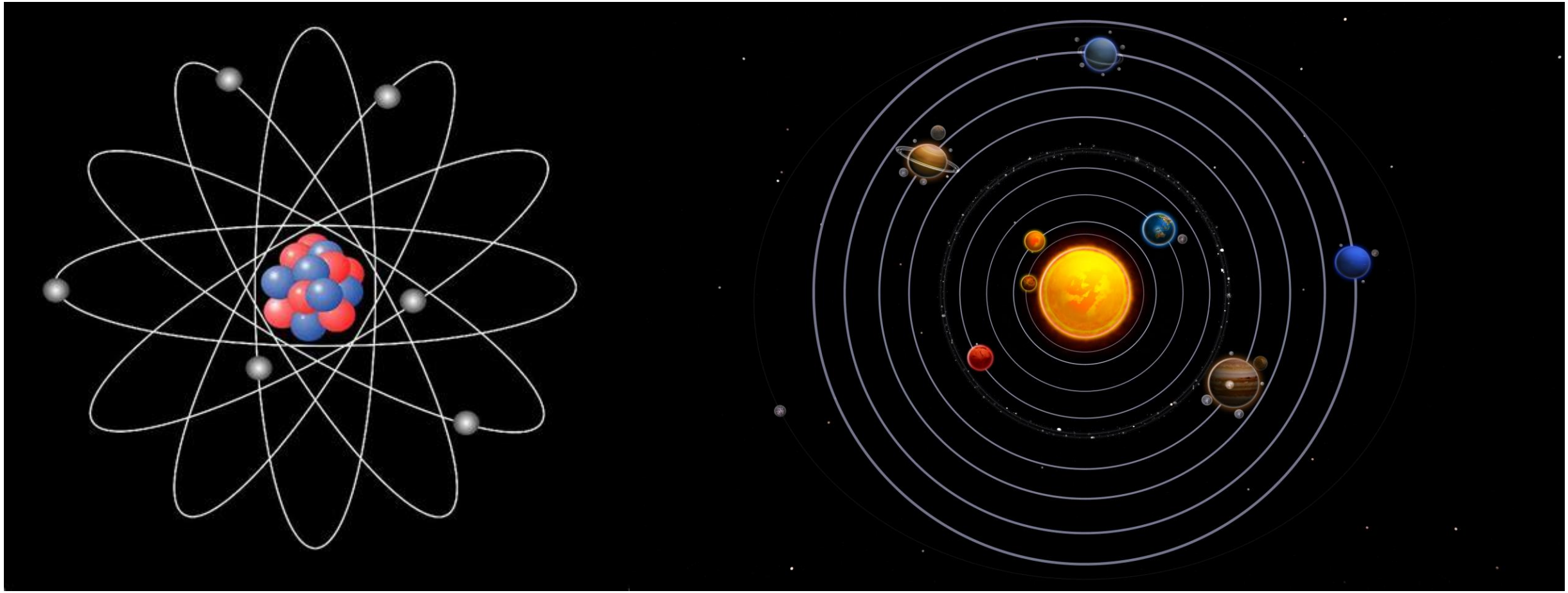
Space is mostly empty

…is a lie. Forget it. False.

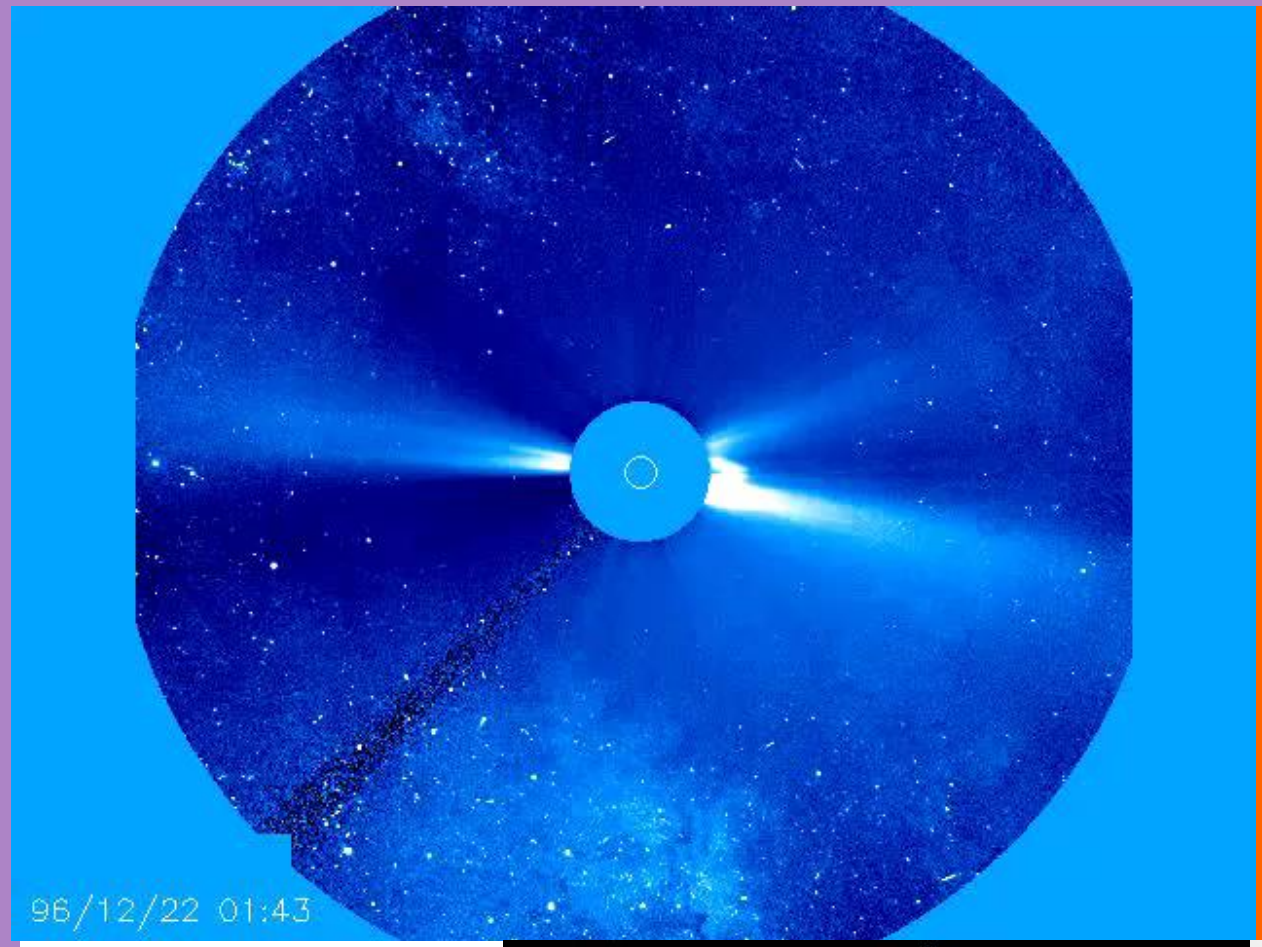

An atom is about 99.999999999% empty space.
curiosity.com
If you removed the empty space from the atoms of all people, the entire human race could fit in the volume of a sugar cube.
Source: Institute of Physics


Atoms consist of 99.99999999% empty space.
That means:
the computer you're looking at,
the chair you're sitting on,
and you, yourself
are mostly NOT THERE.
How awesome is that?!

But is the same thing true about space?



Eris
Kuiper Belt Objects
Neptune
Uranus
Saturn
Jupiter
Asteroid Belt
Mars
Earth
Venus
Mercury
Sun
Pluto
Makemake
Comets
Ceres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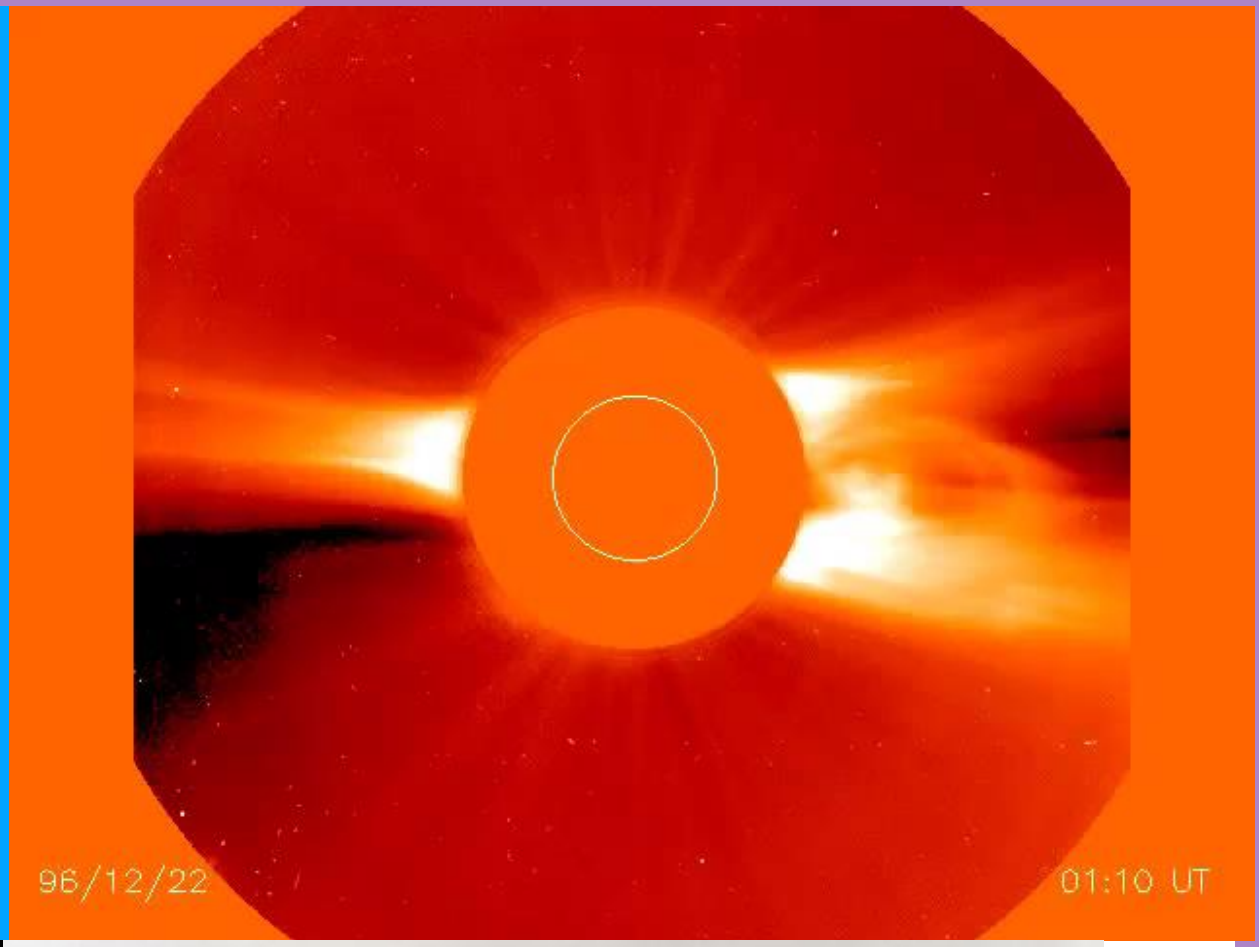
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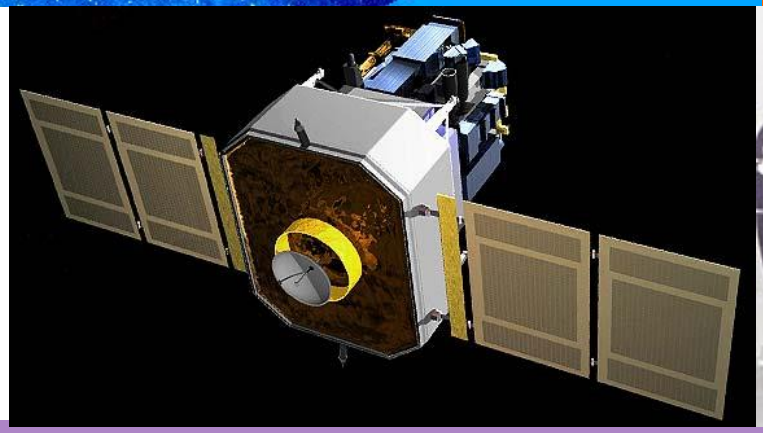
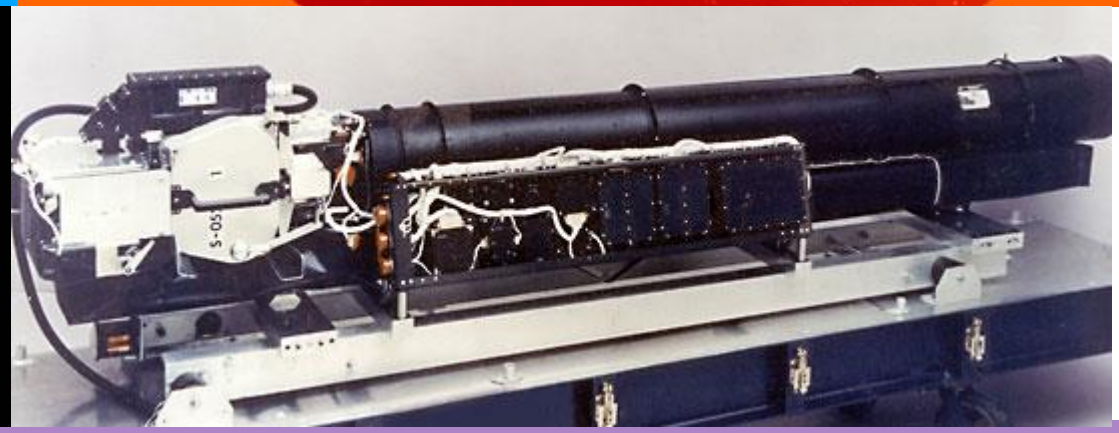
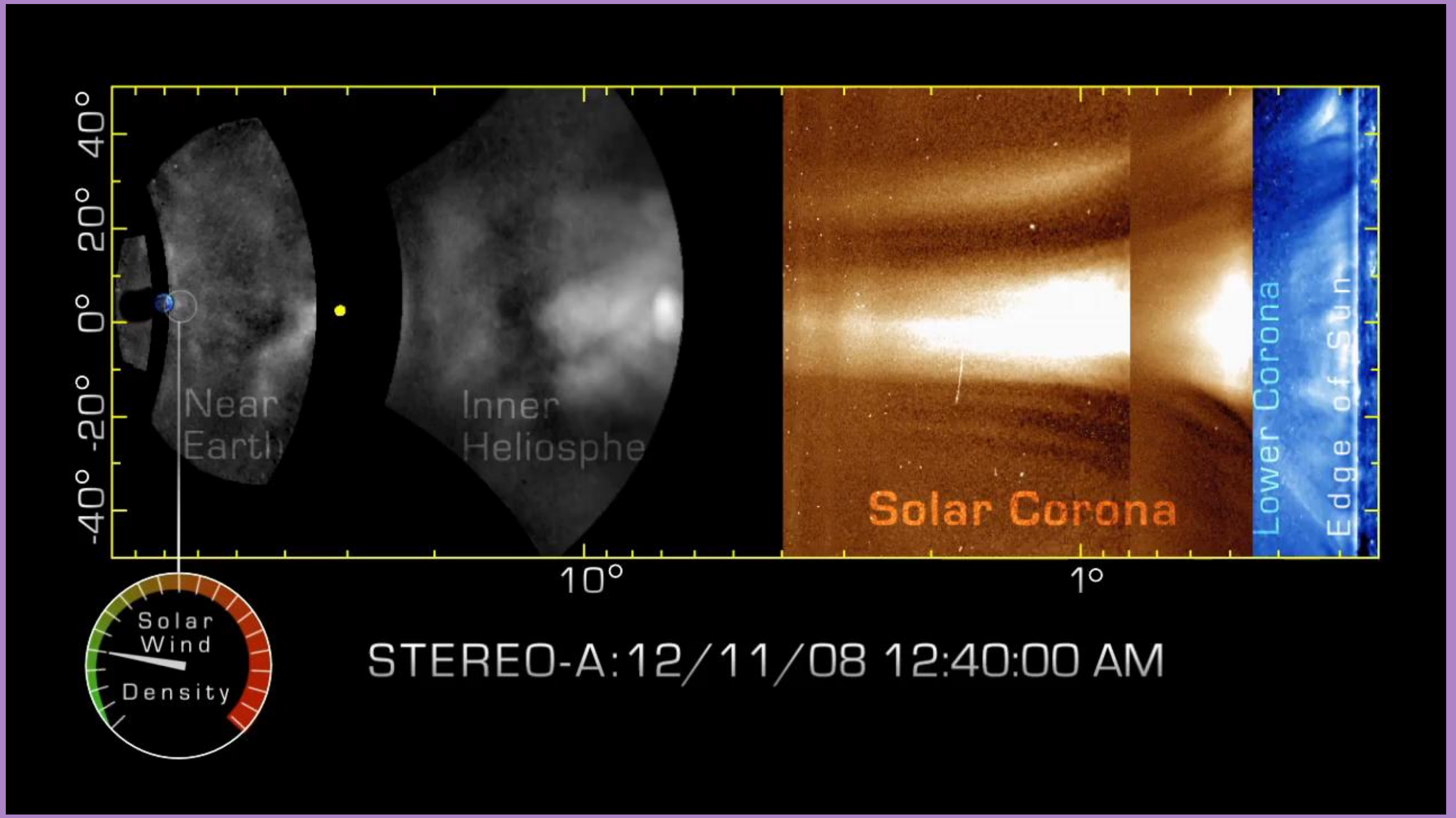
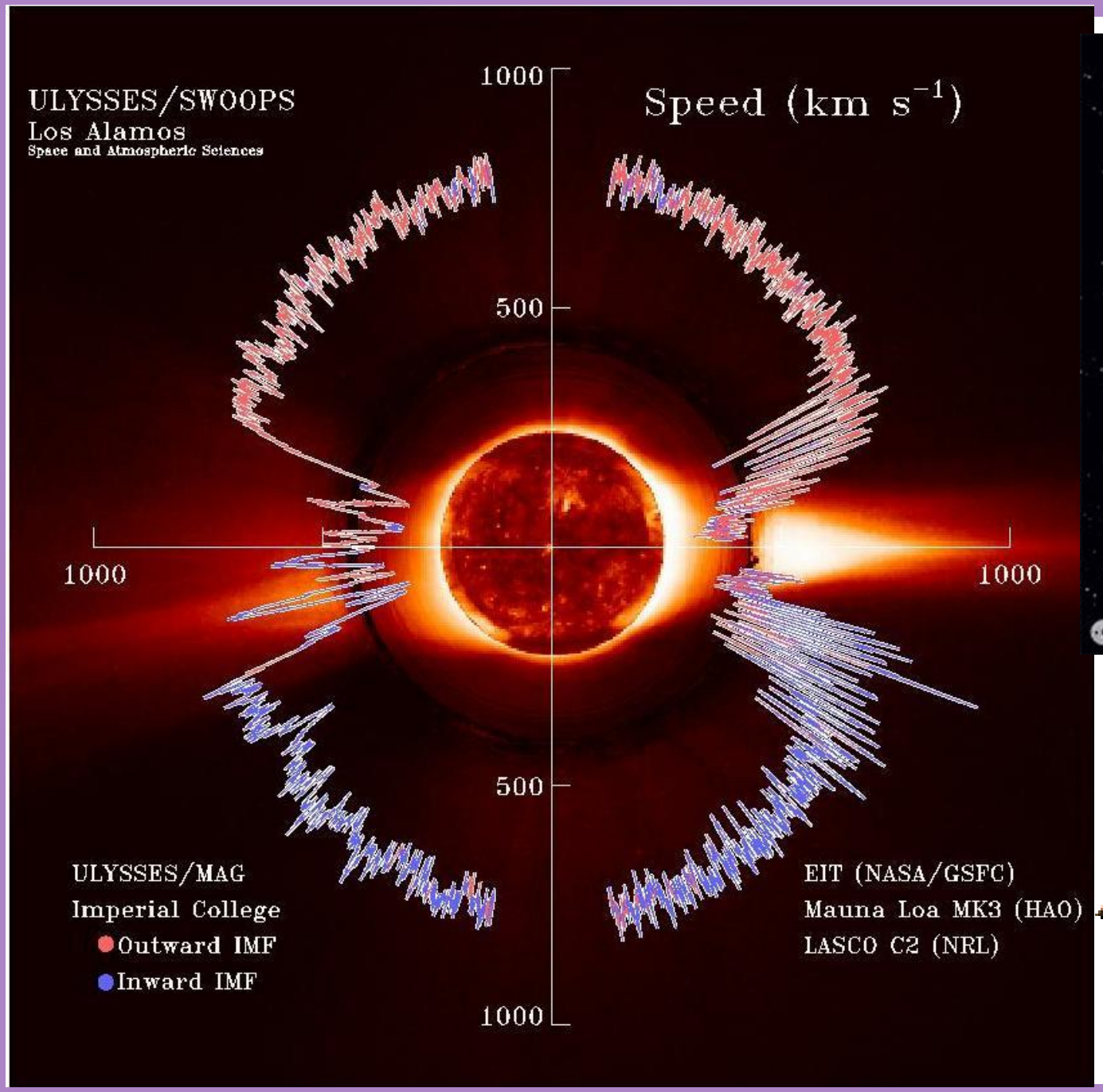
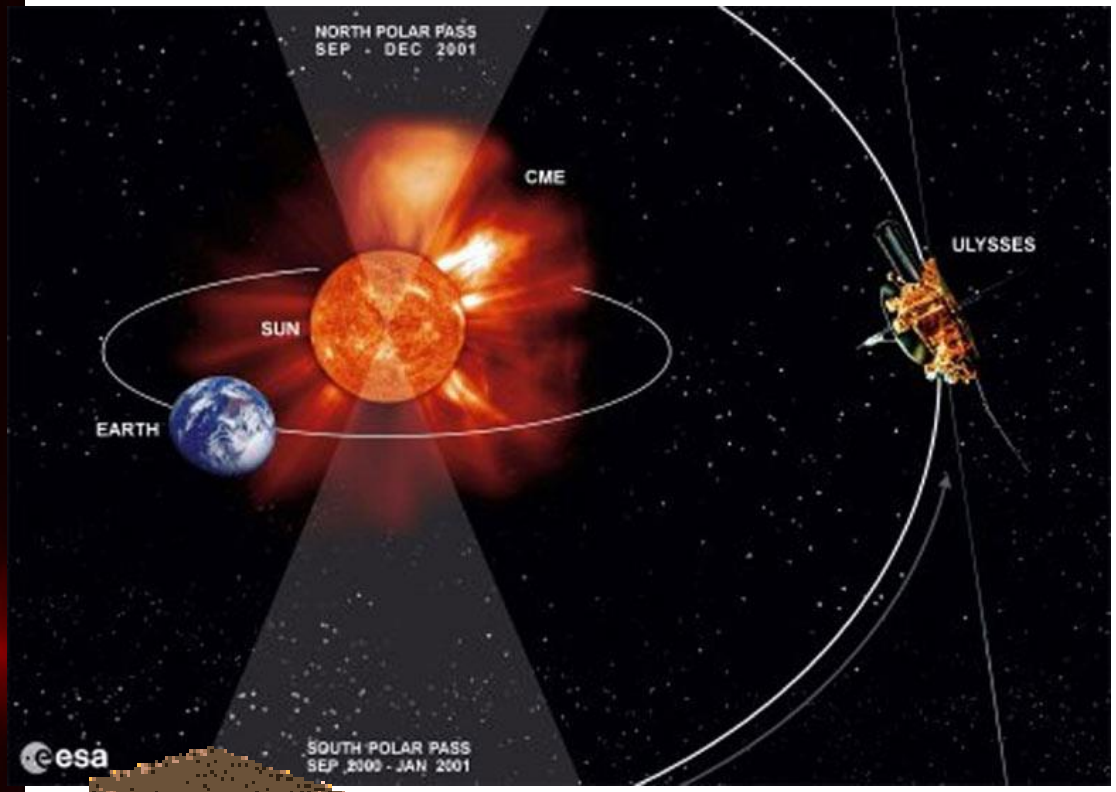
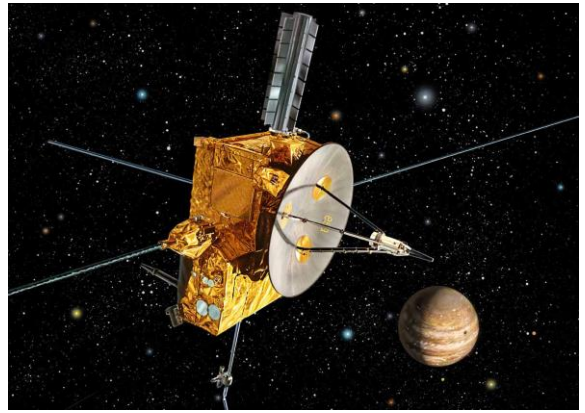


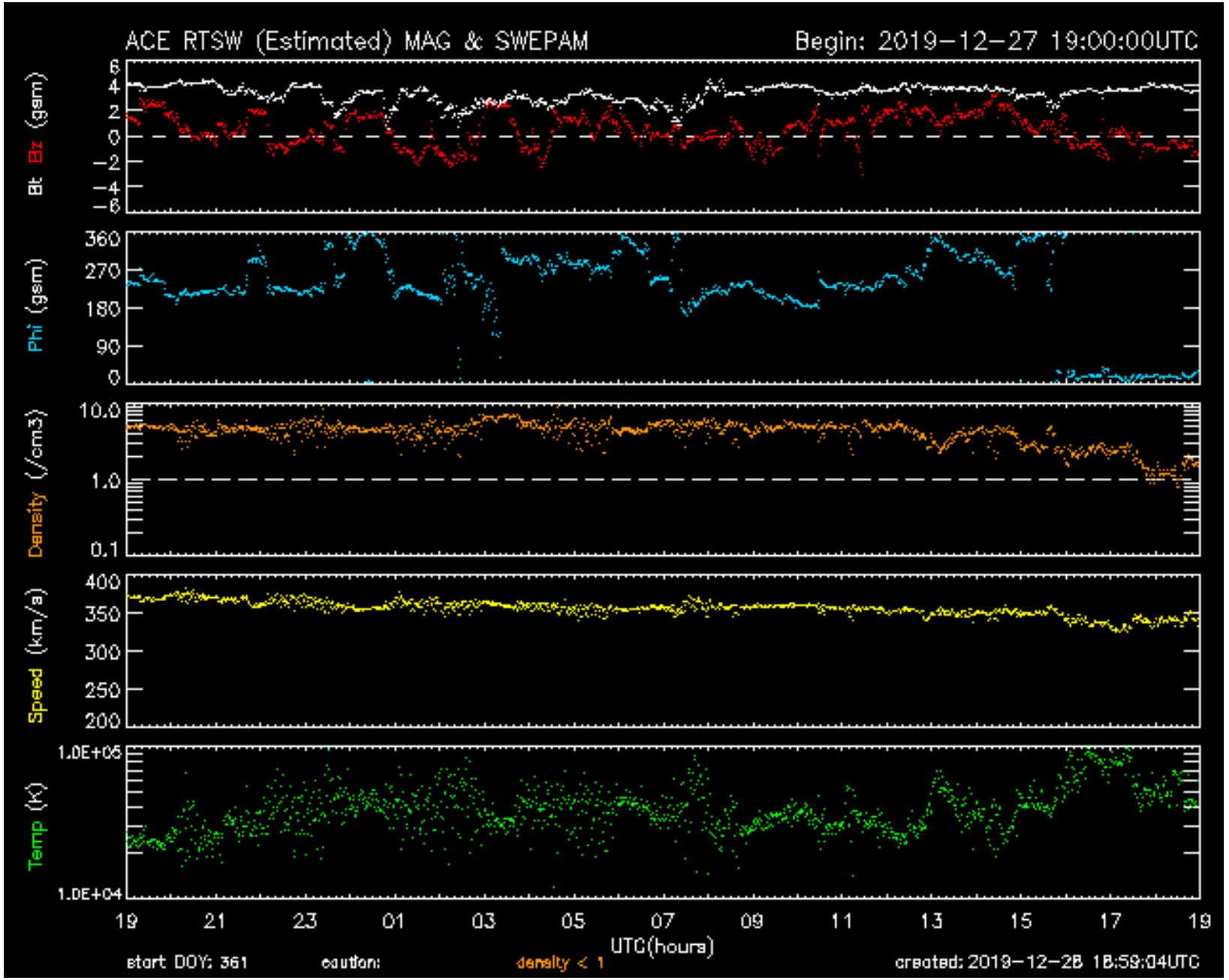



-40° -20° 0° 20° 40°
Near Earth
Inner Heliosphe
Solar Corona
Lower Corona
Edge of Sun
10°
1°
Solar Wind Density
STEREO-A:12/11/08 12:40:00 AM

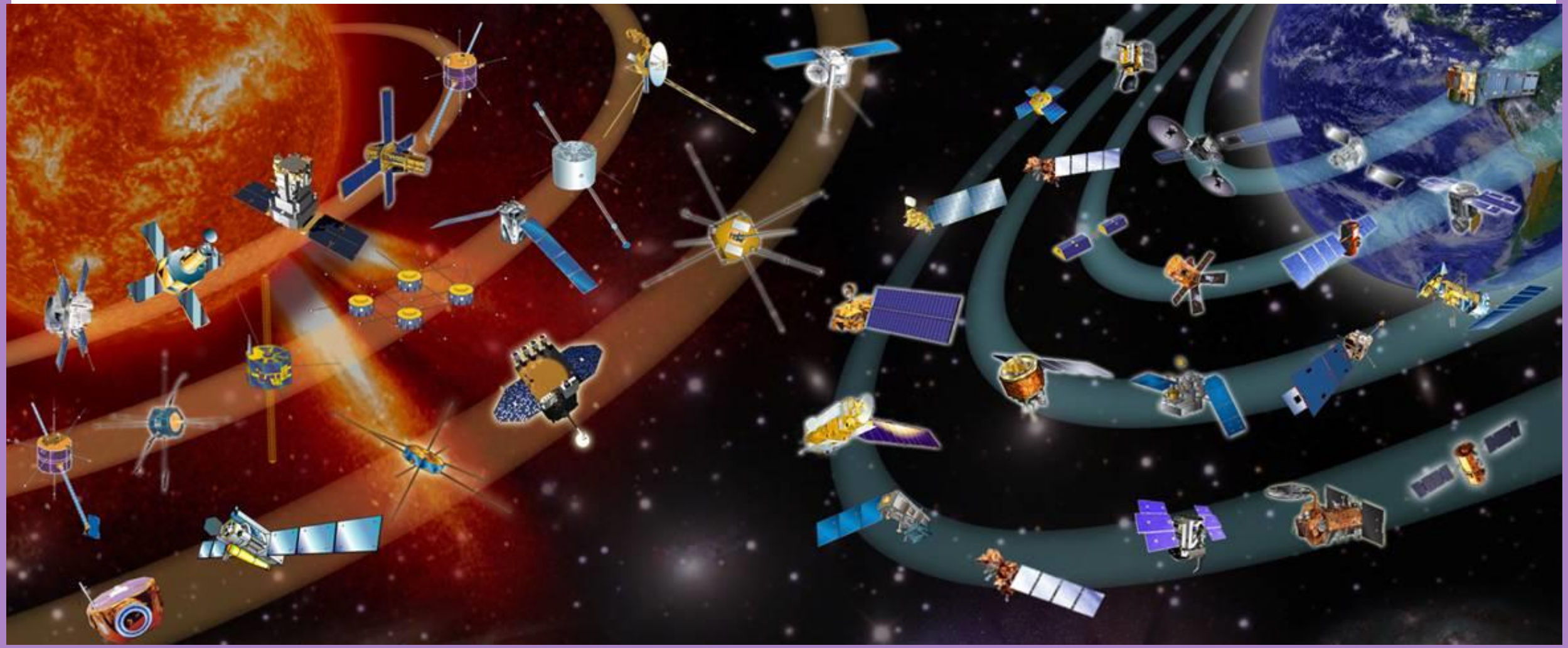

ULYSSES/SWOOPS
Los Alamos
Space and Atmospheric Sciences
Speed (km s^{-1})
1000
500
1000
1000
500
1000
ULYSSES/MAG
Imperial College
Outward IMF
Inward IMF
EIT (NASA/GSFC)
Mauna Loa MK3 (HAO)
LASCO C2 (NRL)

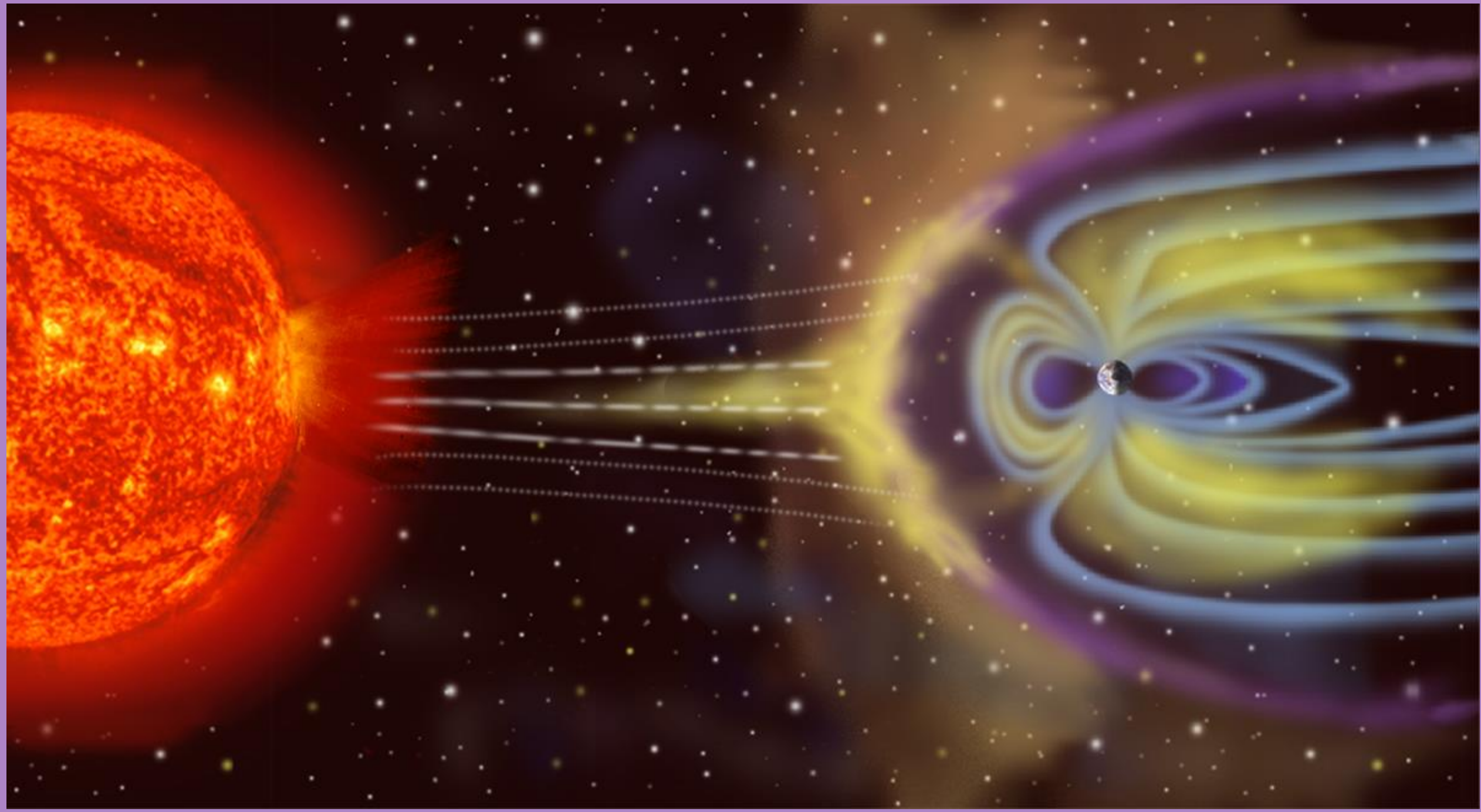

NORTH POLAR PASS
SEP - DEC 2001
CME
ULYSSES
SUN
EARTH
esa
SOUTH POLAR PASS
SEP 2000 - JAN 2001

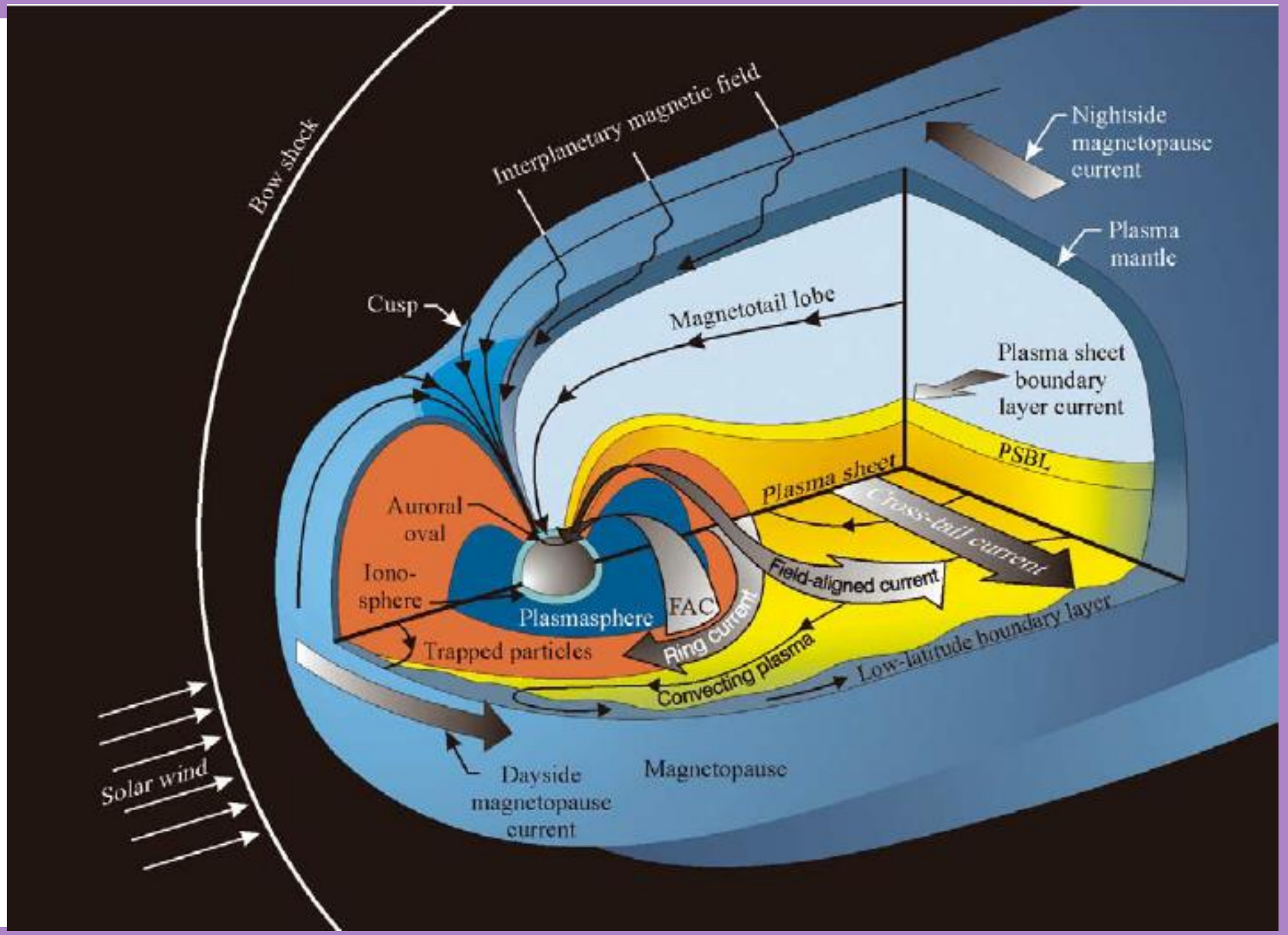


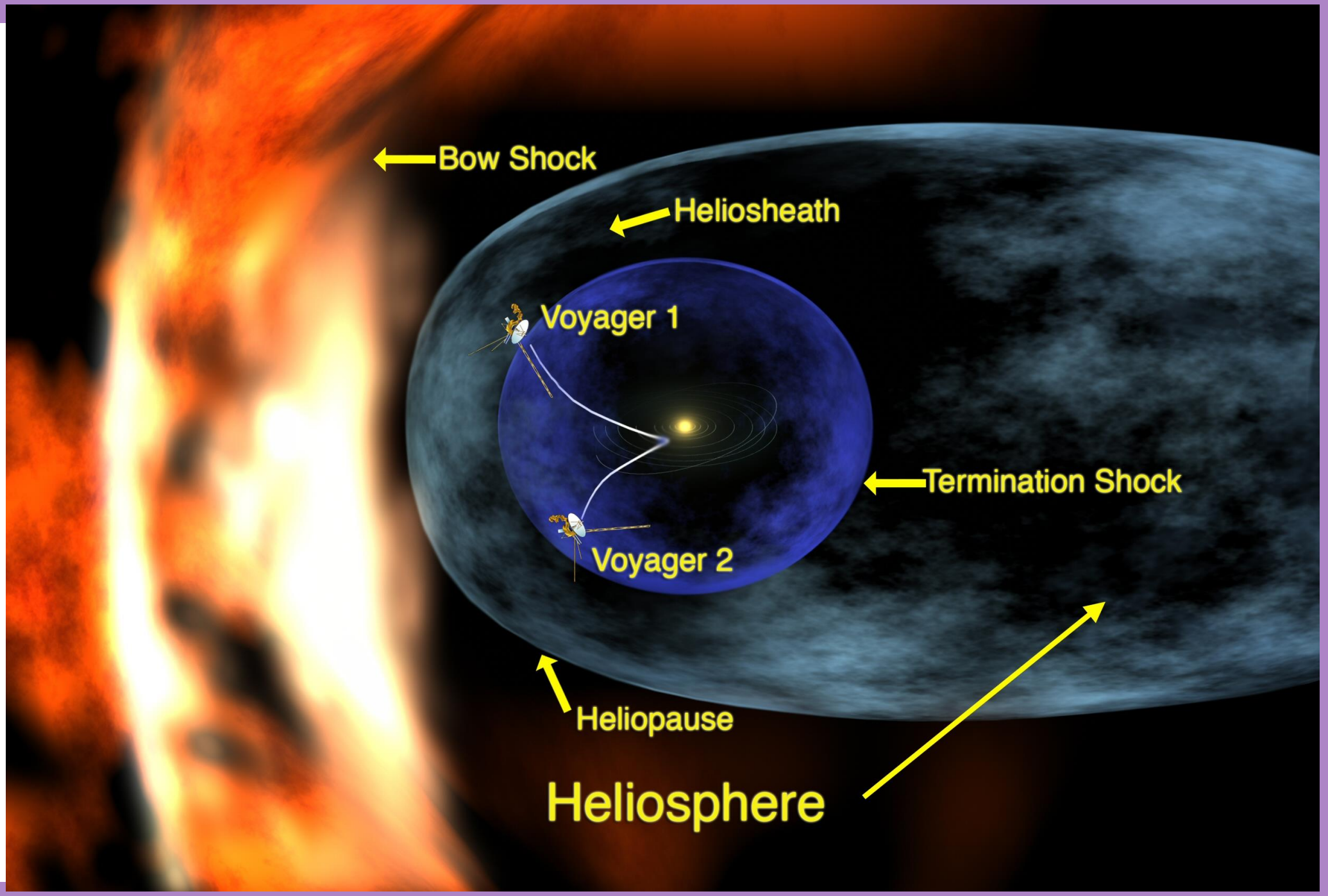

ACE RTSW (Estimated) MAG & SWEPAM
Begin: 2019-12-27 19:00:00UTC
Bt Bz (gsm)
6
4
2
0
-2
-4
-6
Phi (gsm)
360
270
180
90
0
Density (/cm3)
10.0
1.0
0.1
Speed (km/s)
400
350
300
250
200
Temp (K)
1.0E+06
1.0E+04
19
21
23
01
03
05
07
09
11
13
15
17
19
UTC(hours)
start DOY: 361
caution:
density < 1
created: 2019-12-28 18:59:04UTC

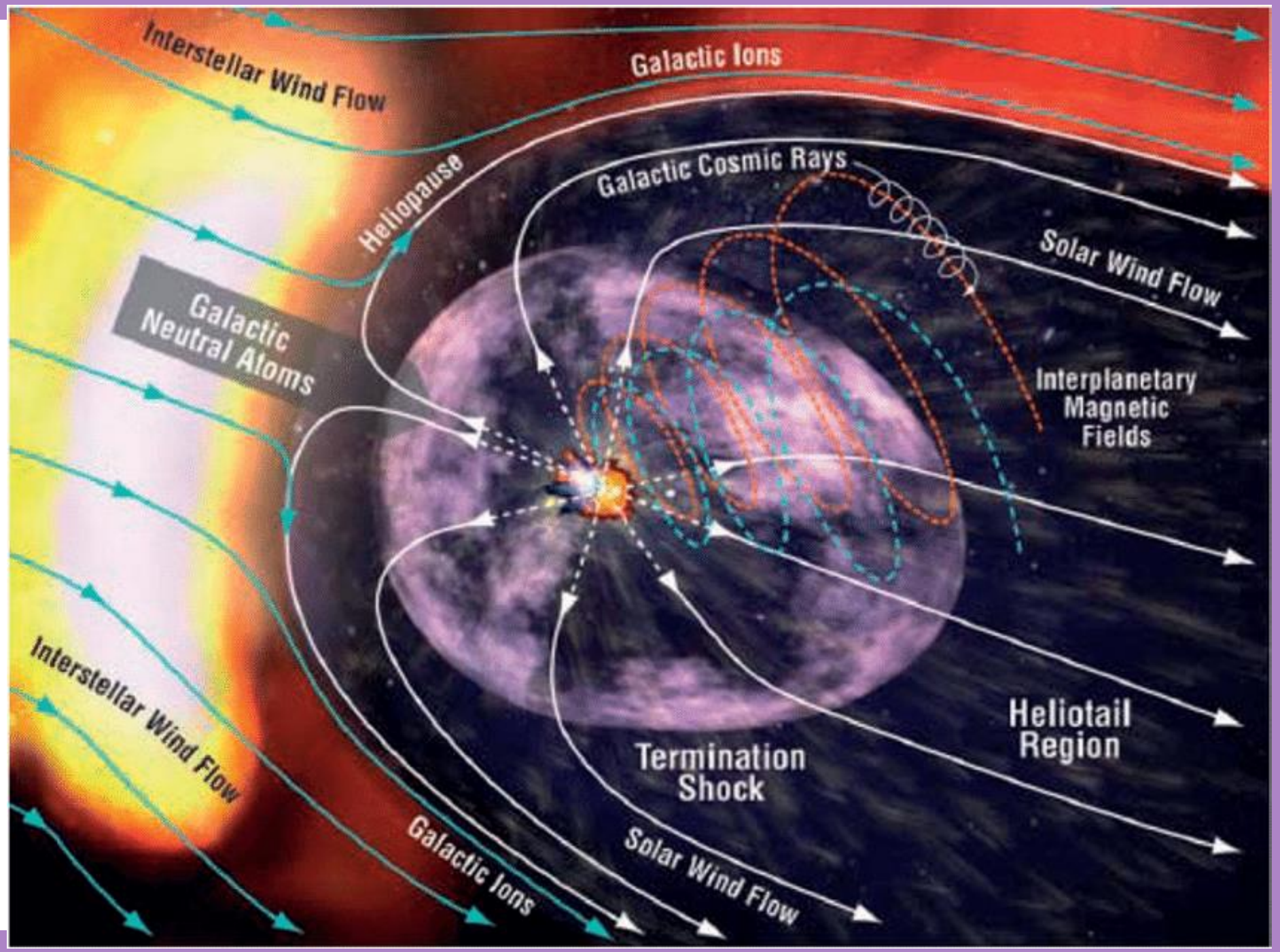
Spacecraft, Remote and In-situ

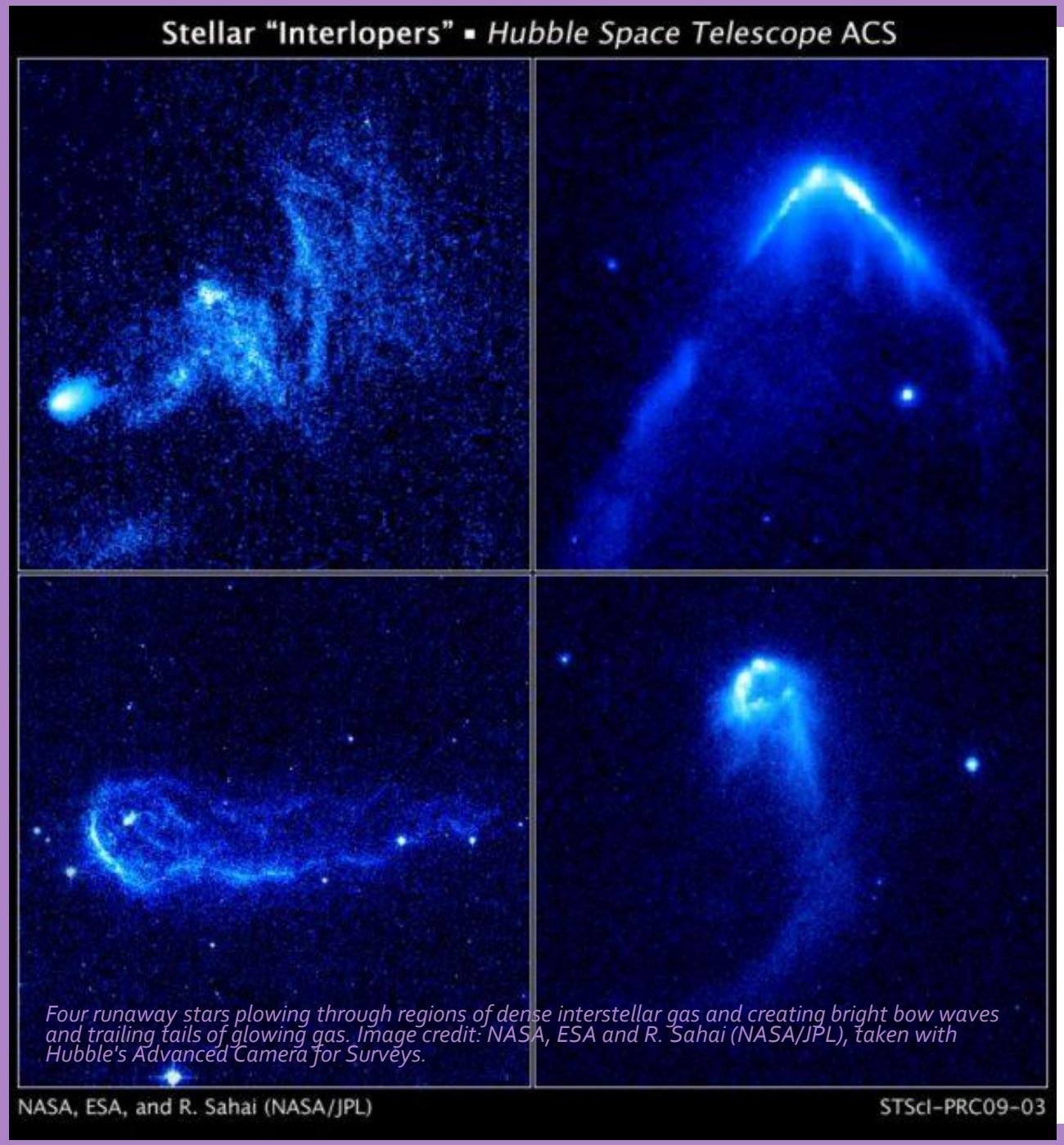




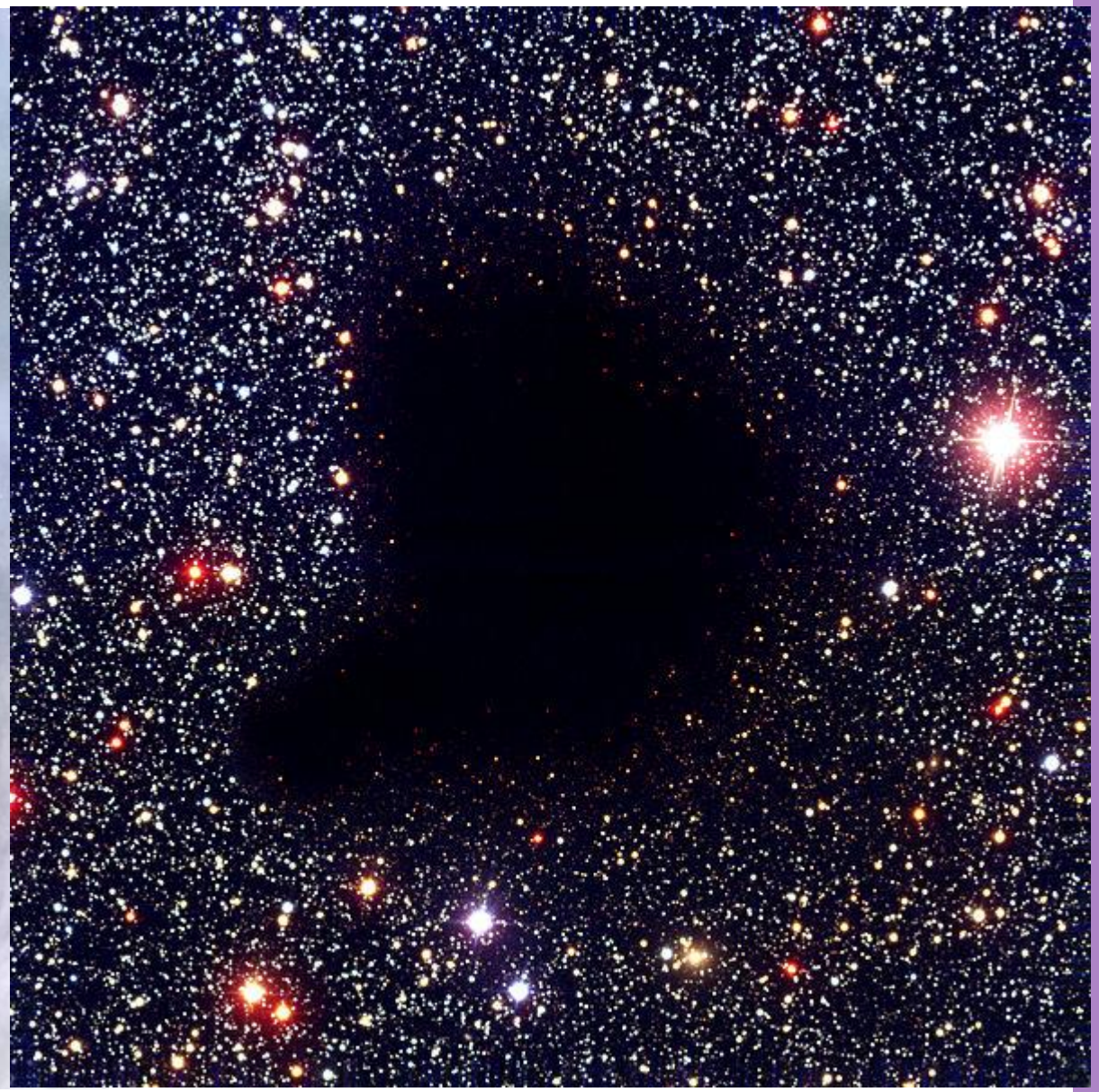

Bow shock
Interplanetary magnetic field
Nightside magnetopause current
Plasma mantle
Cusp
Magnetotail lobe
Plasma sheet boundary layer current
PSBL
Plasma sheet
Cross-tail current
Auroral oval
Iono-sphere
Field-aligned current
FAC
Plasmasphere
Ring current
Trapped particles
Convecting plasma
Low-latitude boundary layer
Solar wind
Dayside magnetopause current
Magnetopause

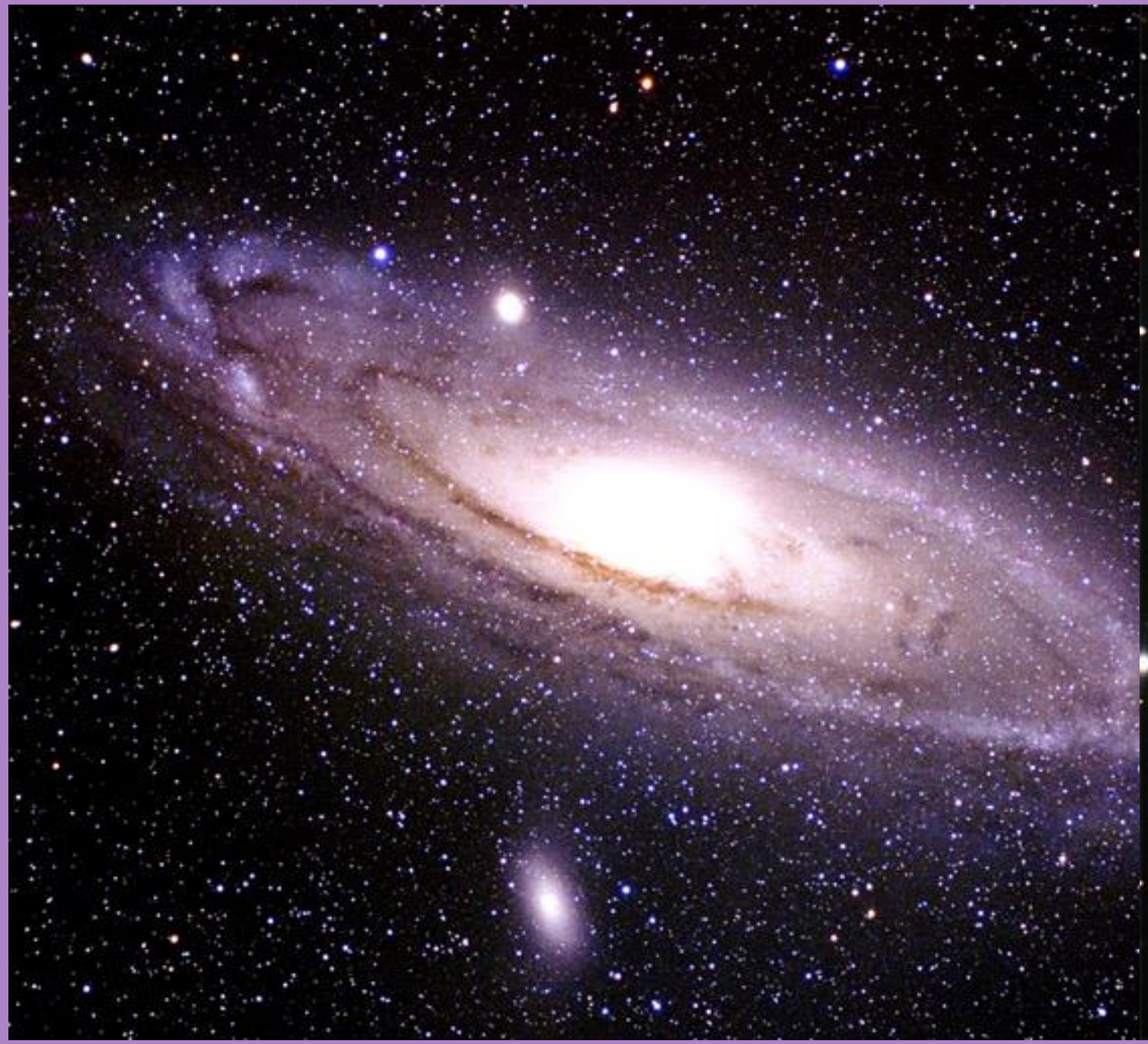

Bow Shock
Heliosheath
Voyager 1
Termination Shock
Voyager 2
Heliopause
Heliosphere

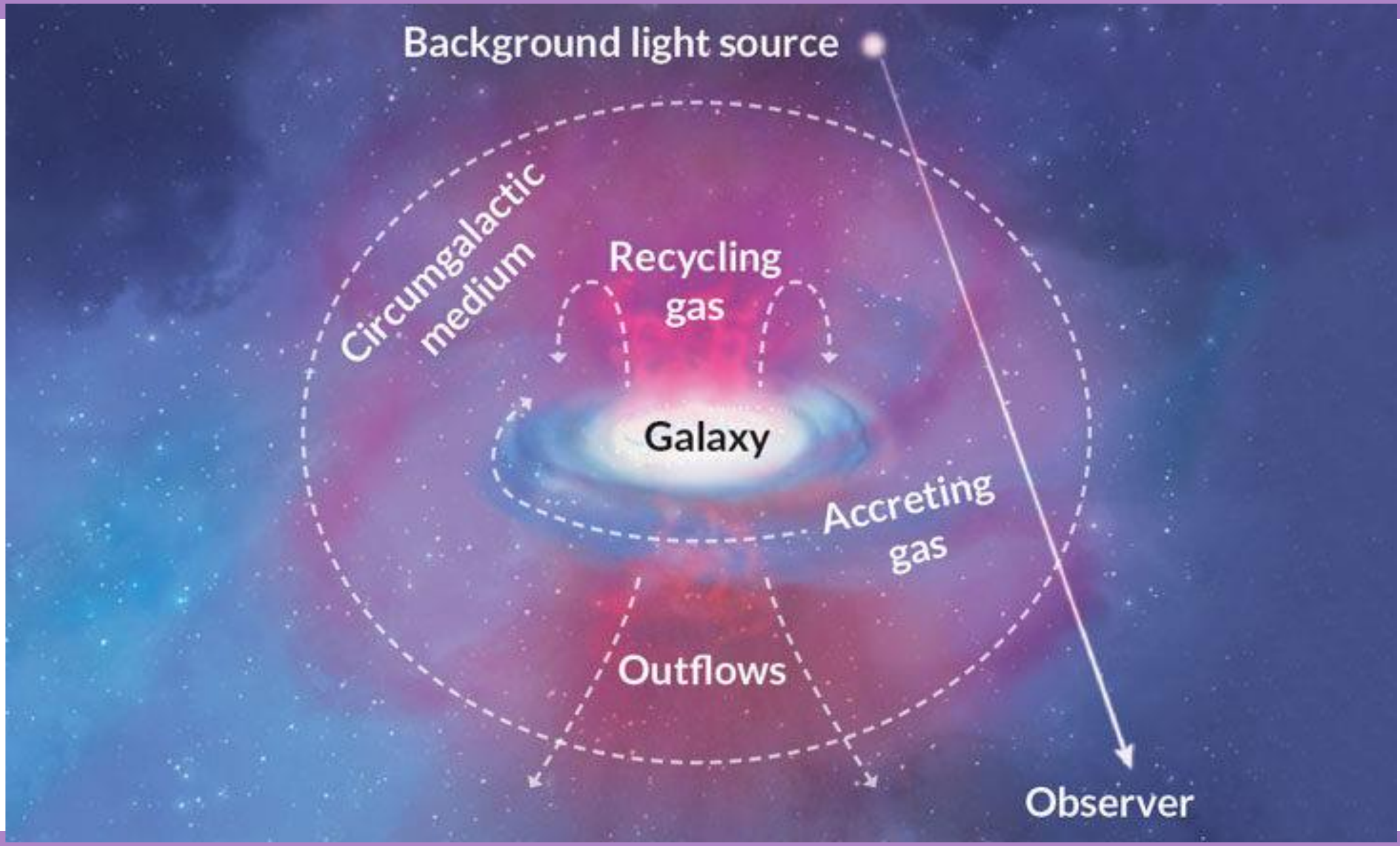

Interstellar Wind Flow
Galactic Ions
Heliopause
Galactic Cosmic Rays
Solar Wind Flow
Galactic Neutral Atoms
Interplanetary Magnetic Fields
Heliotail Region
Termination Shock
Interstellar Wind Flow
Galactic Ions
Solar Wind Flow

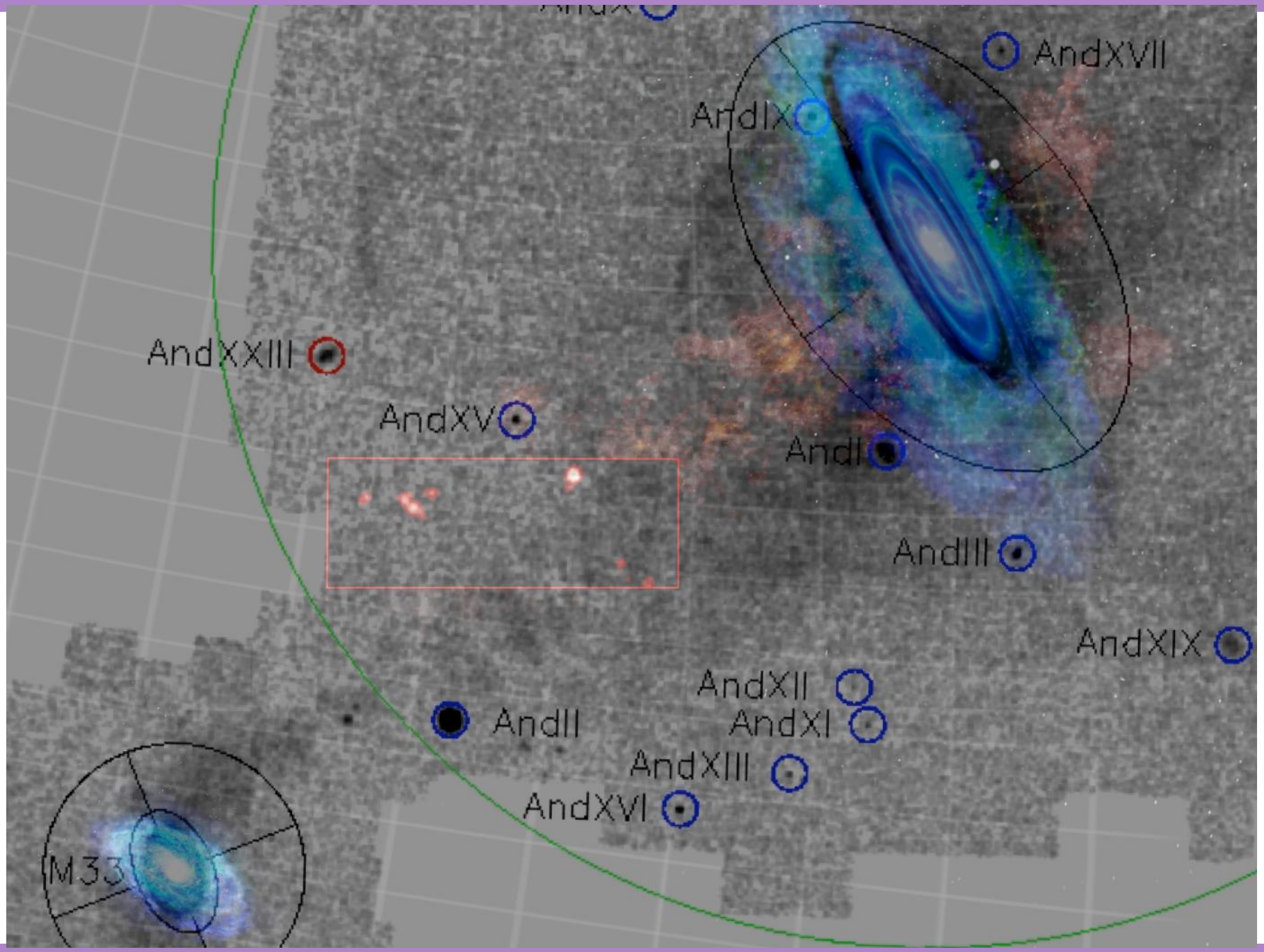


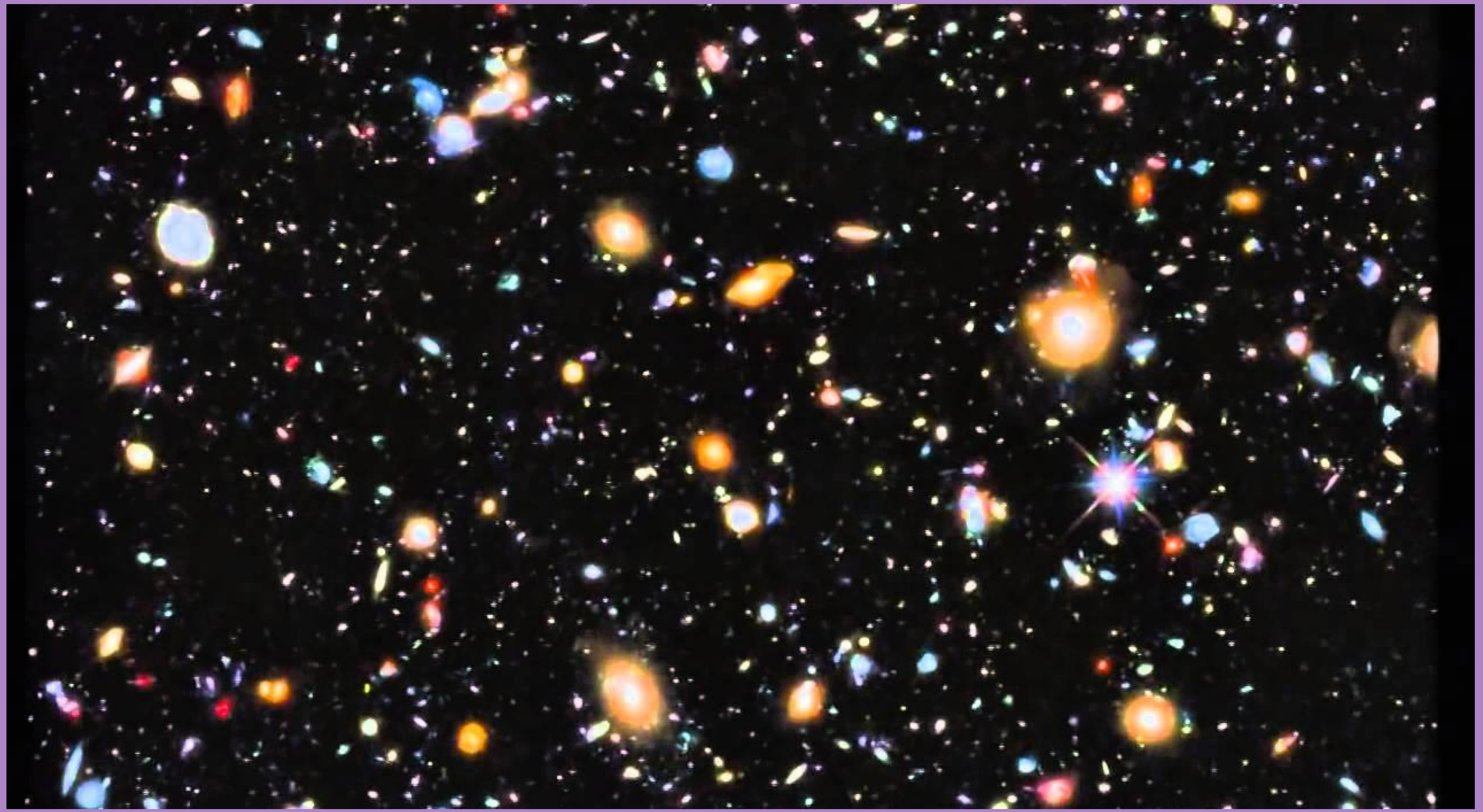
Ocean Between Stars

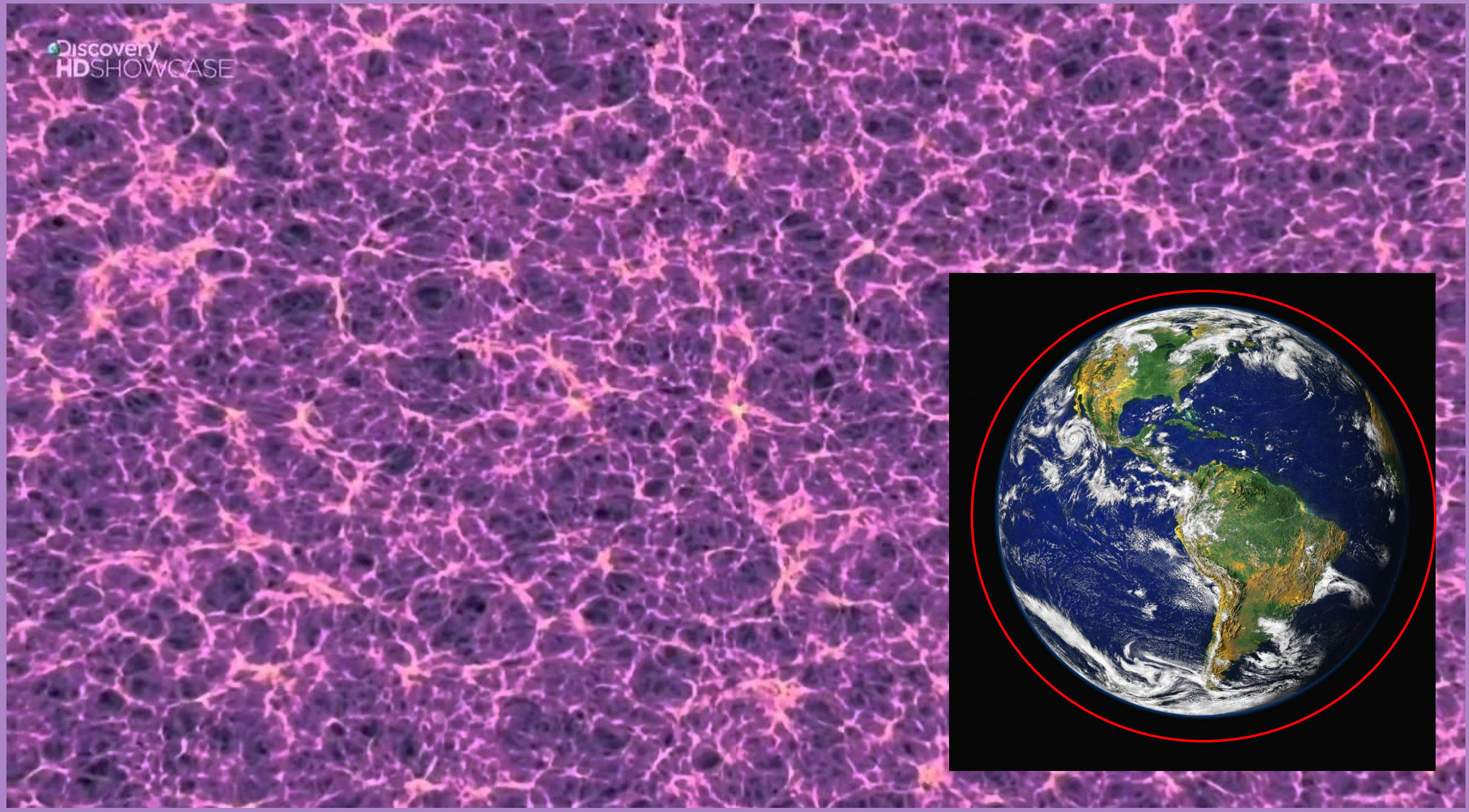




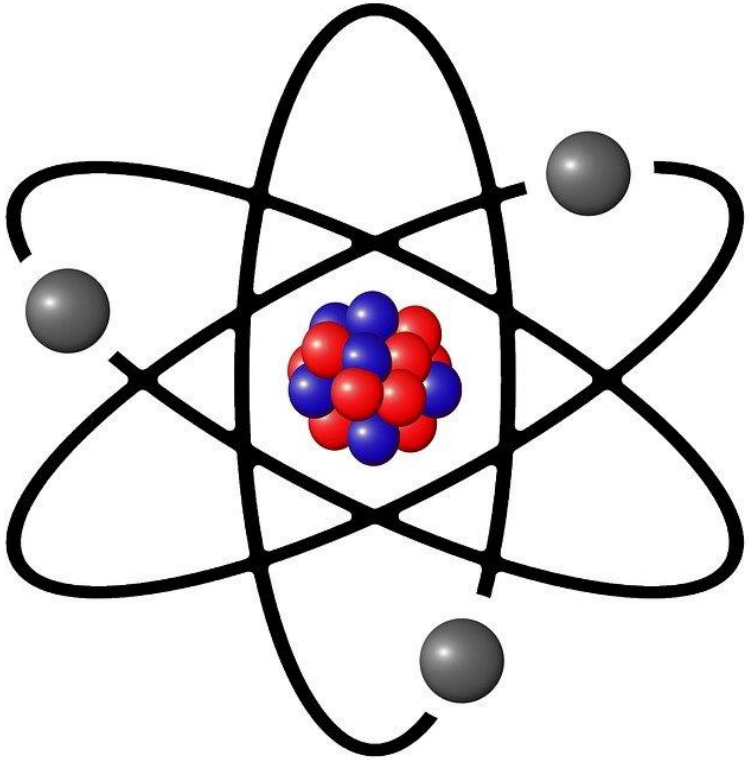

Background light source
Circumgalactic medium
Recycling gas
Galaxy
Accreting gas
Outflows
Observer

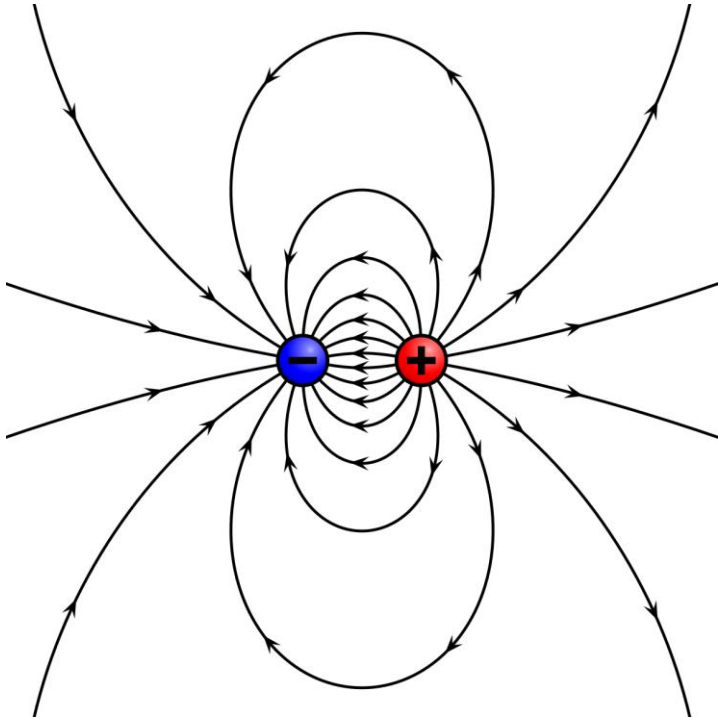

AndXVII
AndIX
AndXXIII
AndXV
AndI
AndIII
AndXIX
AndXII
AndXI
AndII
AndXIII
AndXVI
M33



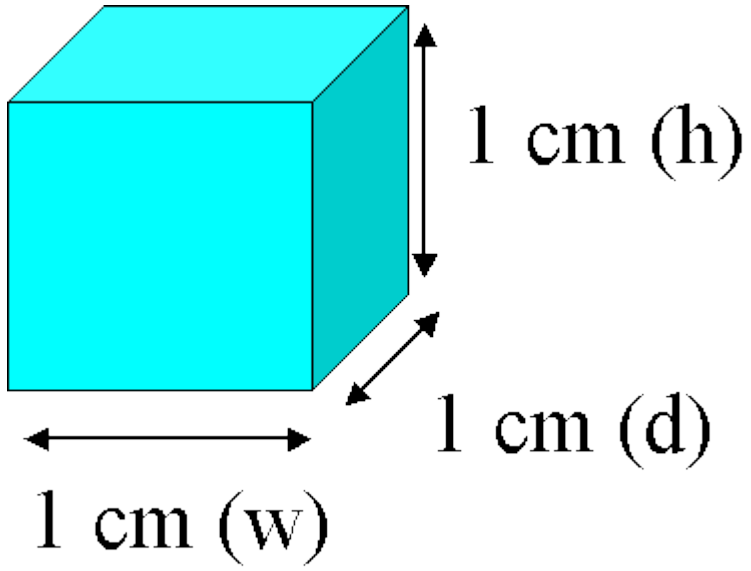

Discovery
HDSHOWCASE

That's enough about big stuff…what about small stuff?

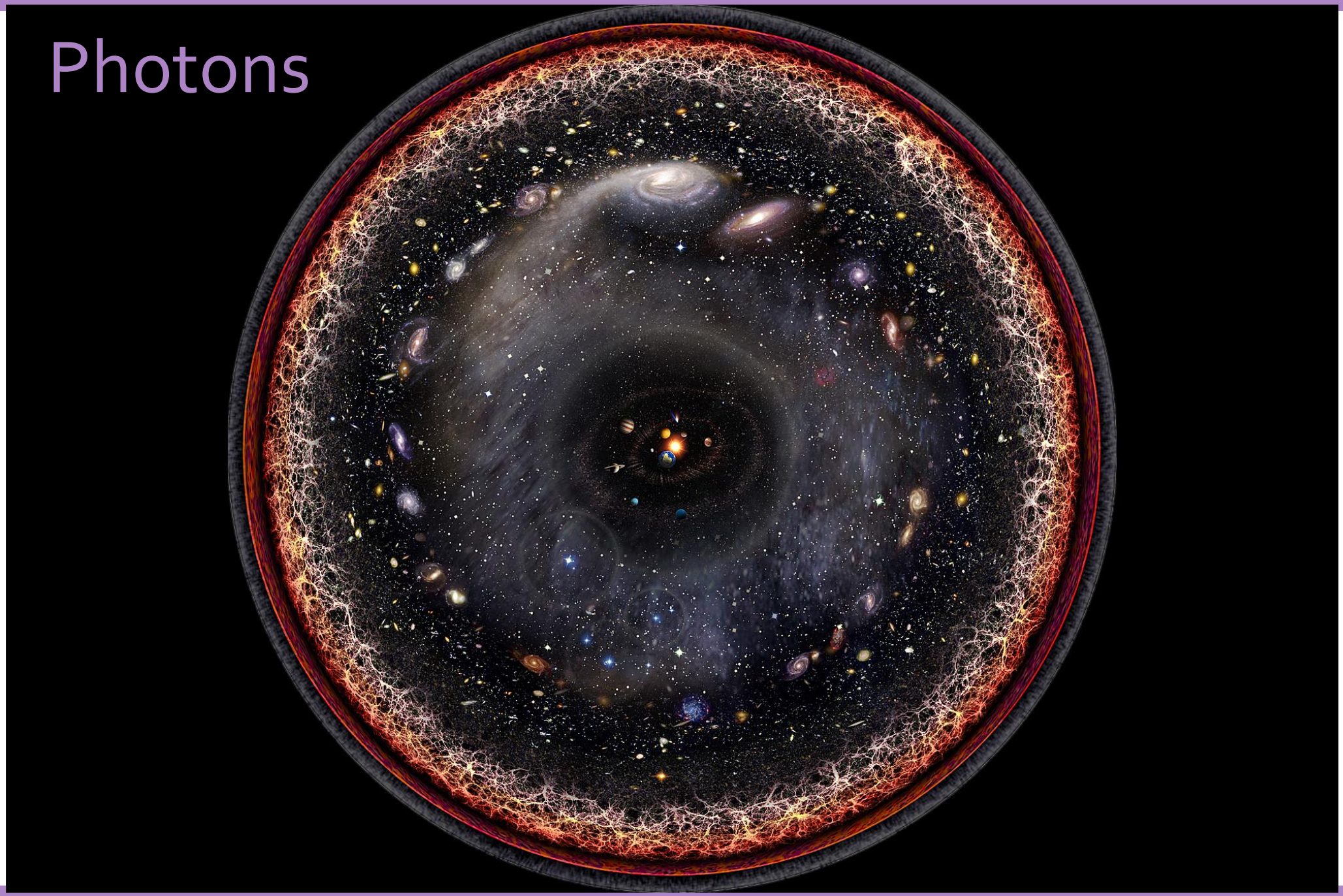




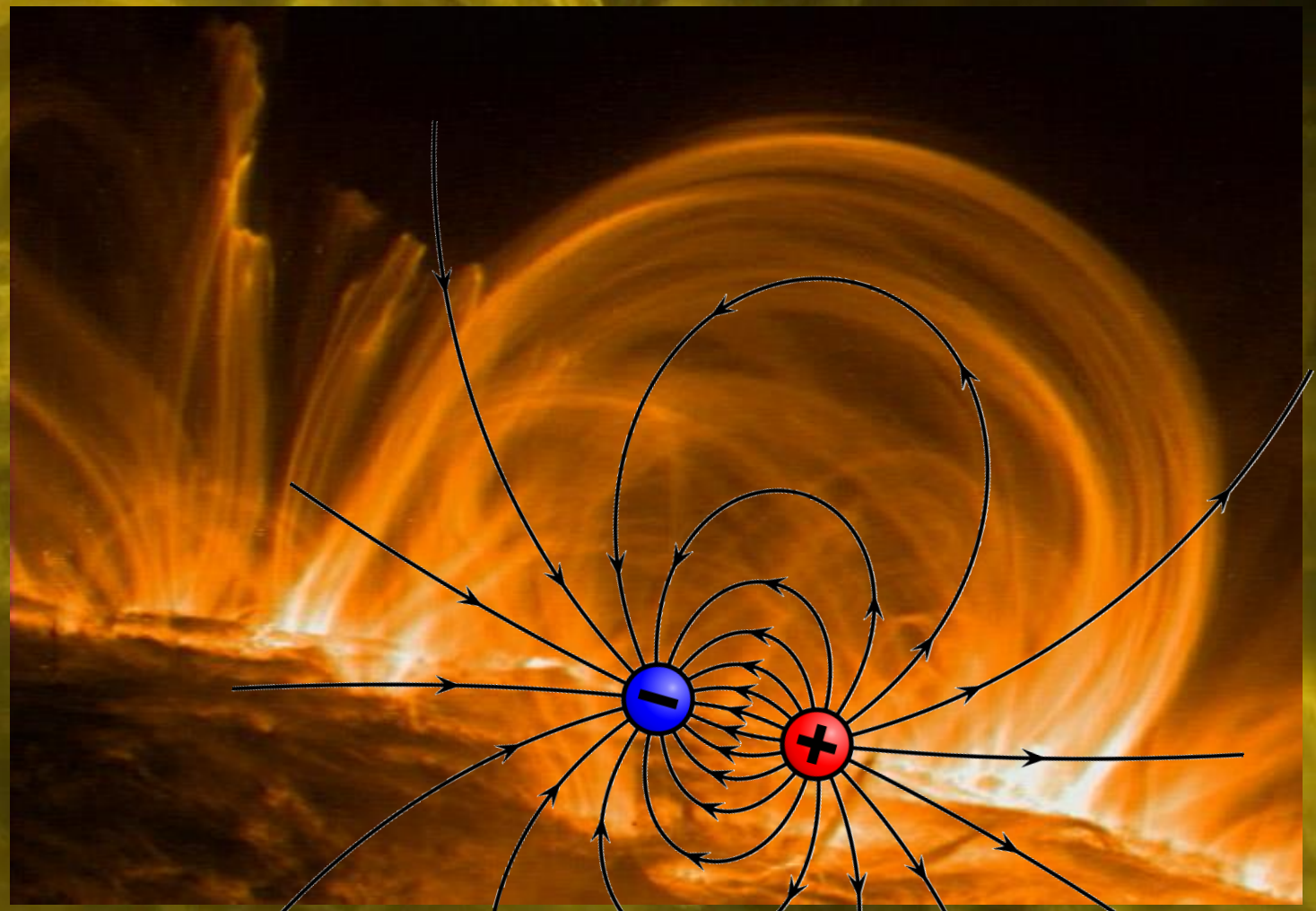
Lets imagine just a tiny cube of “nothing” deep in space

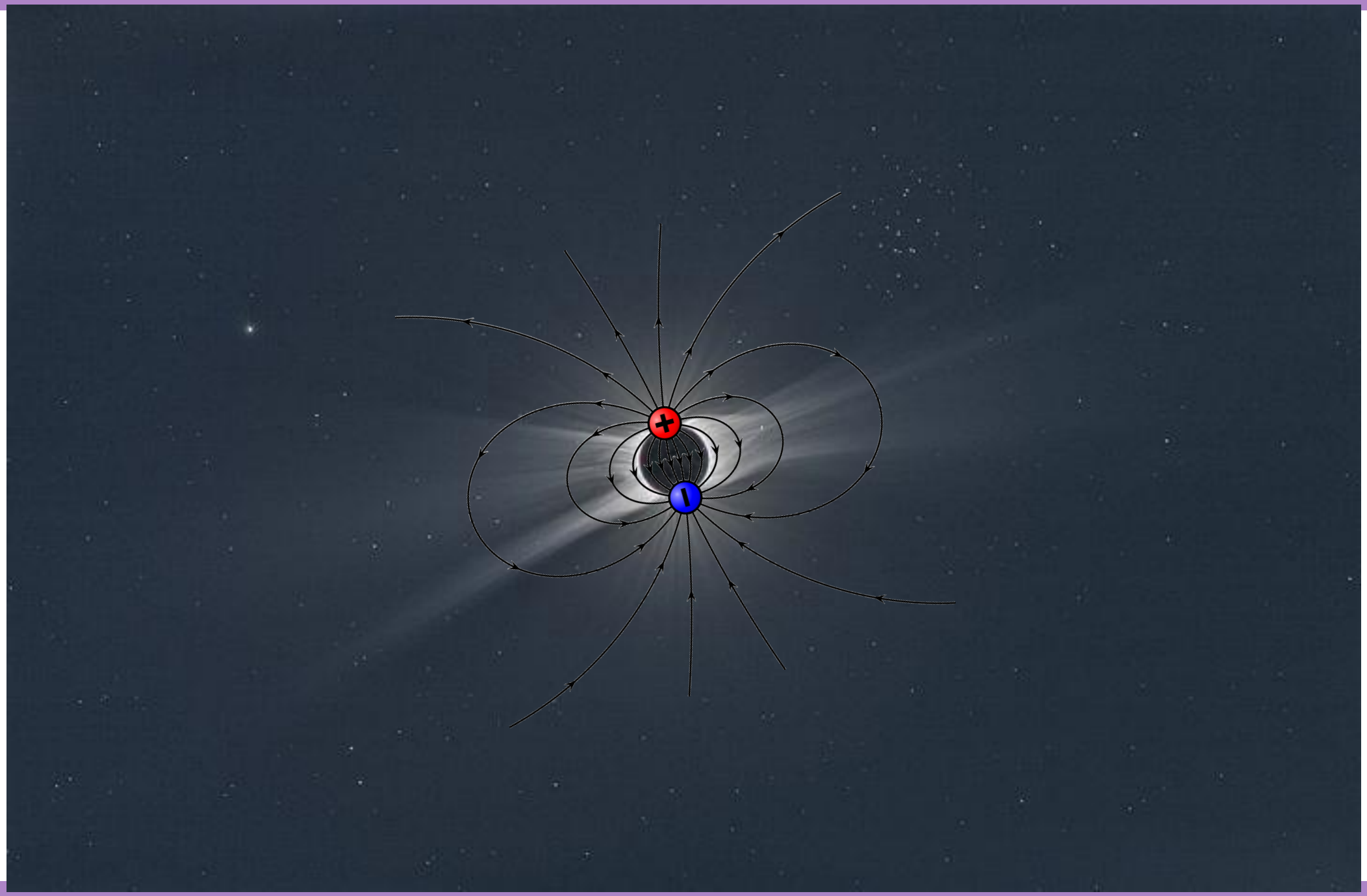


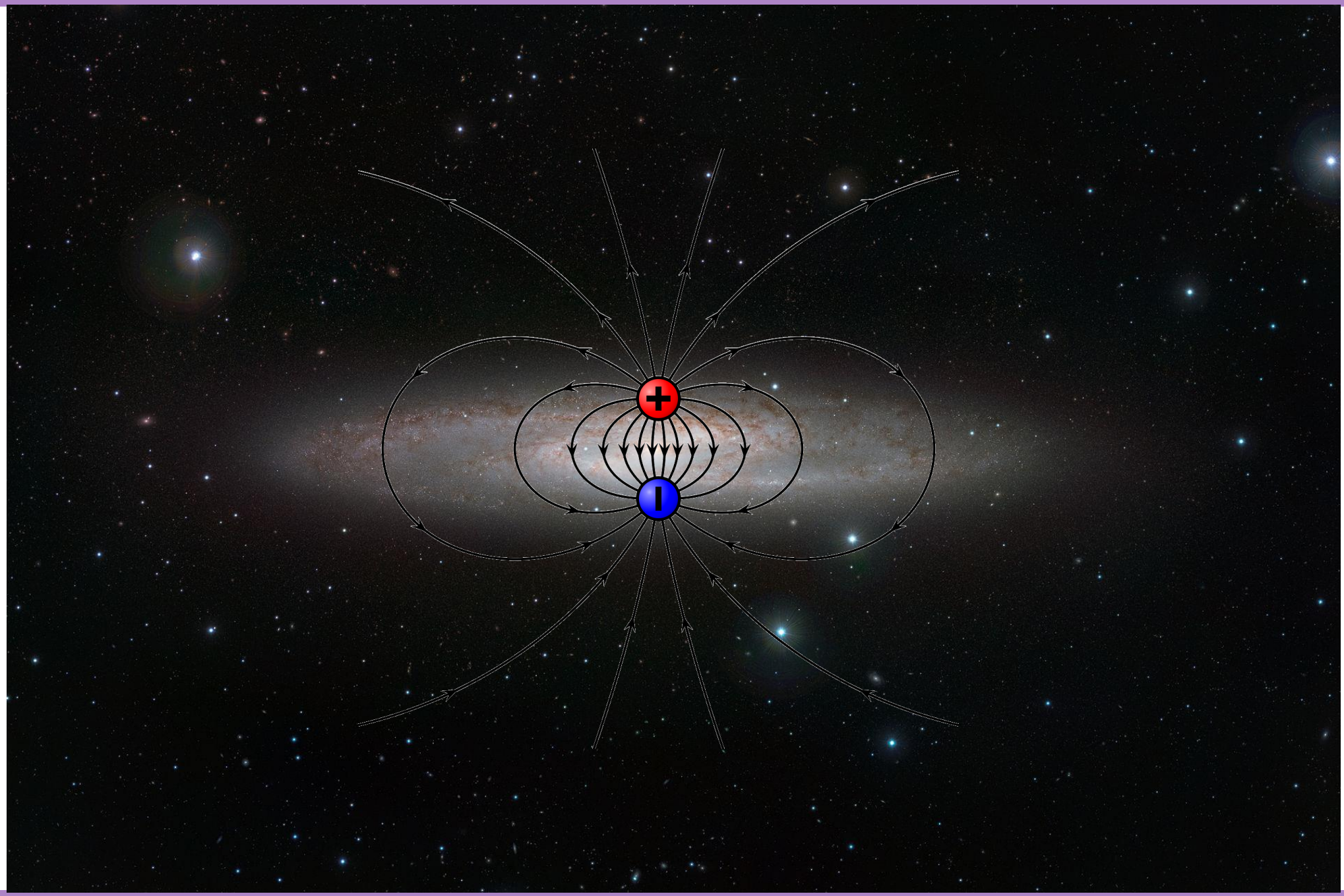
Photons



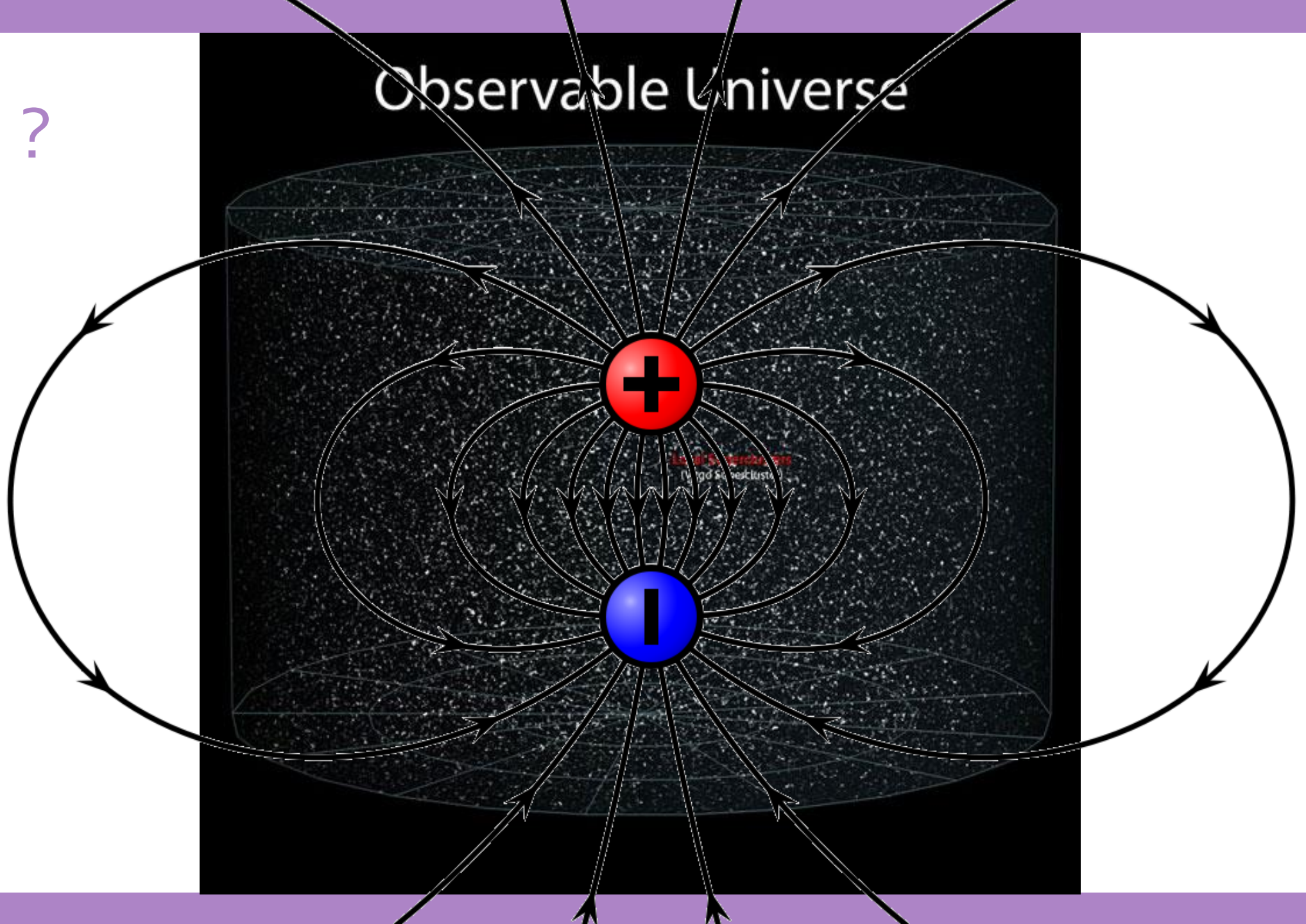
Magnetic Fields



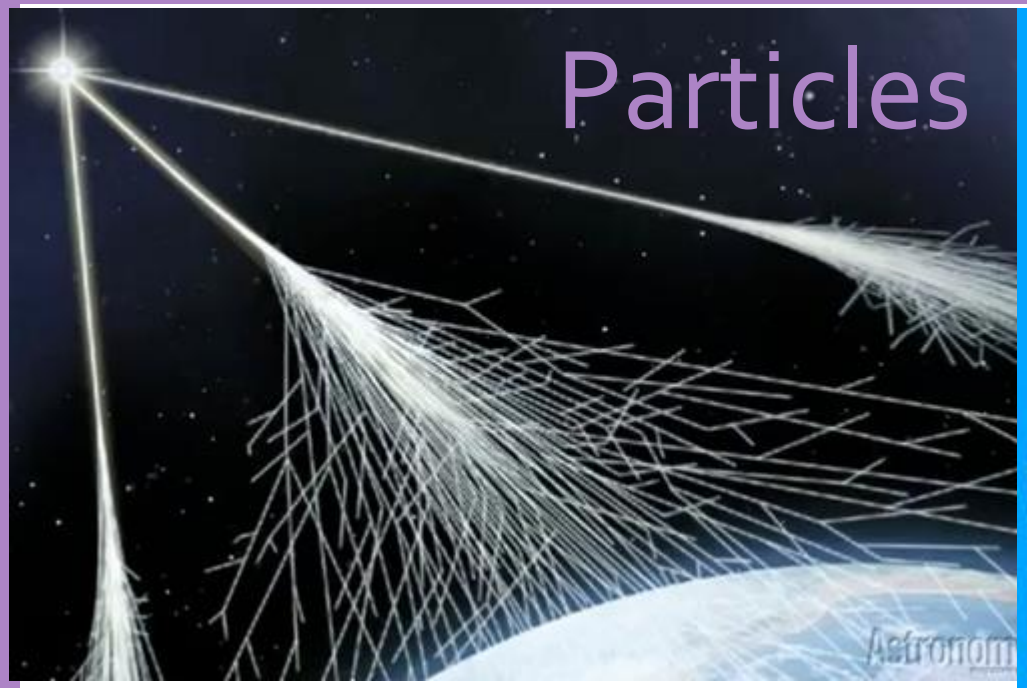


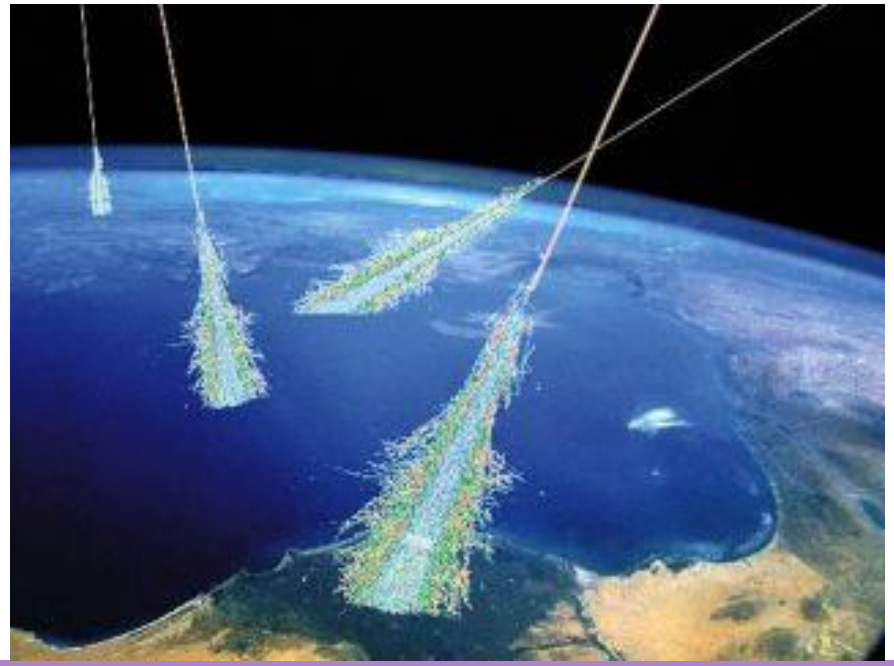


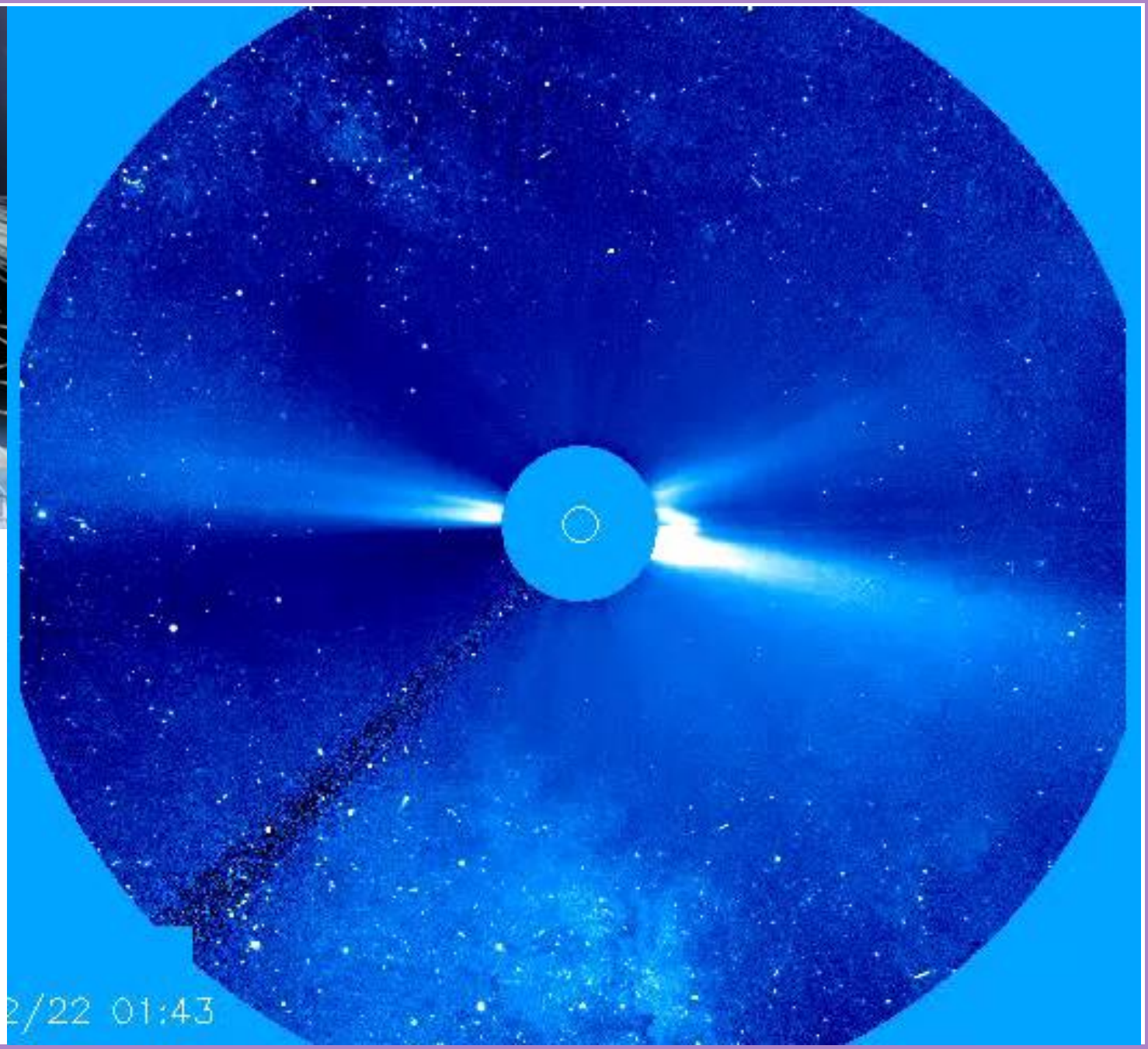
?


Observable Universe

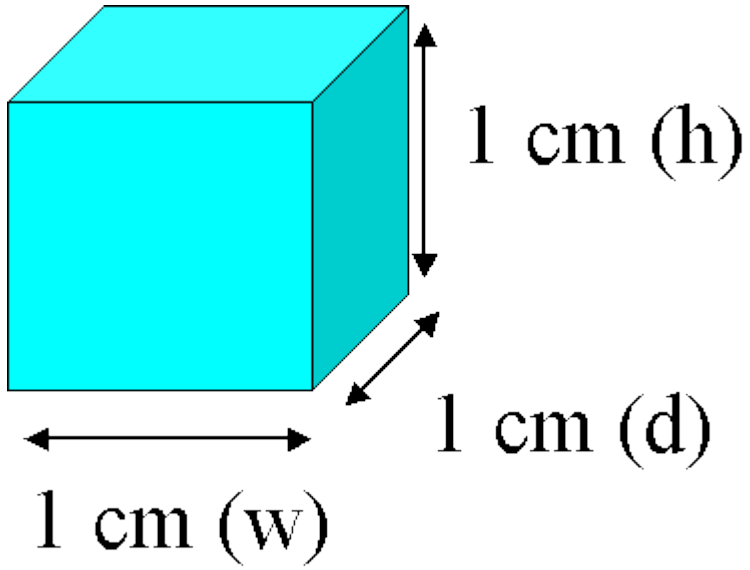
Particles



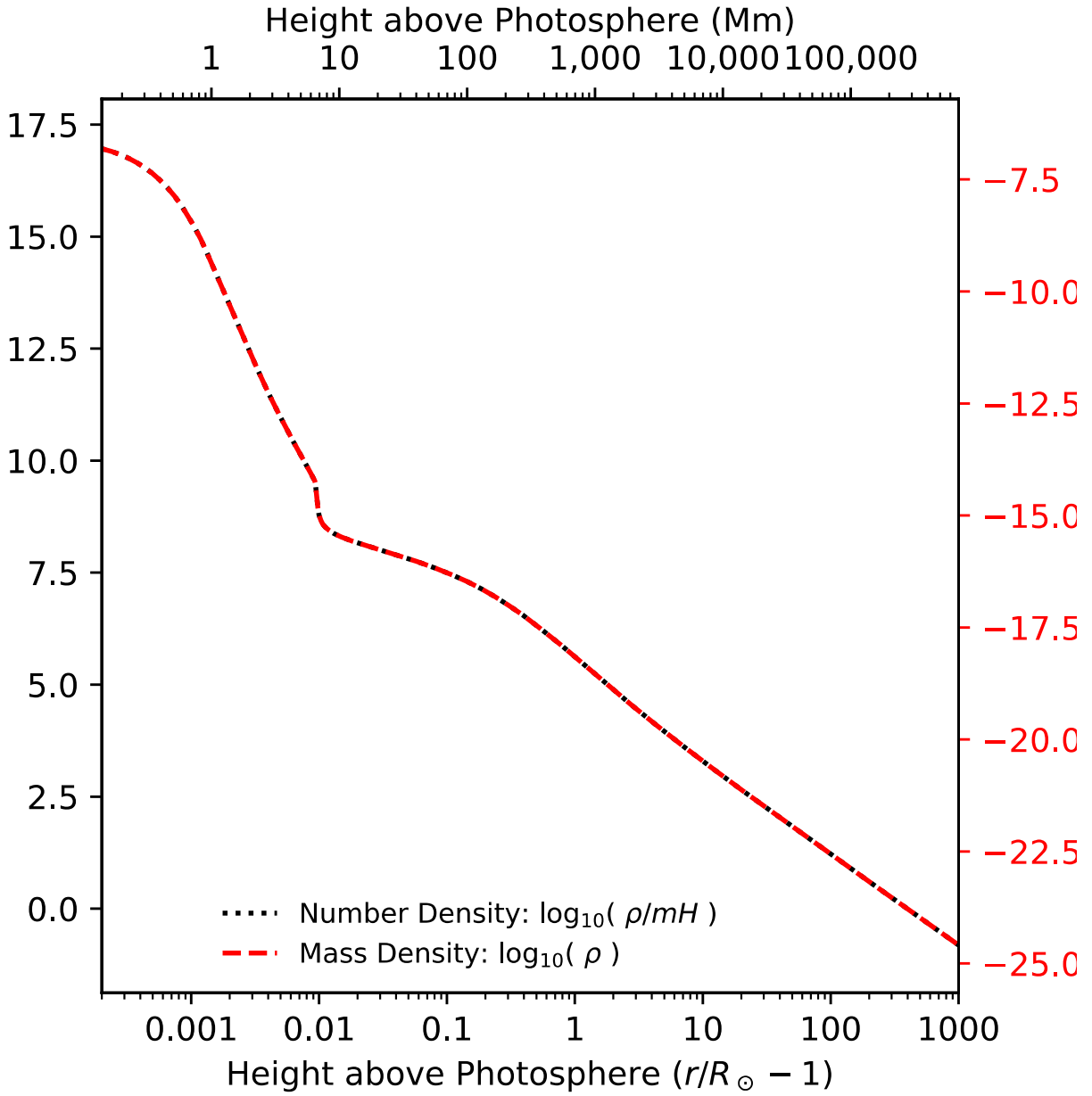




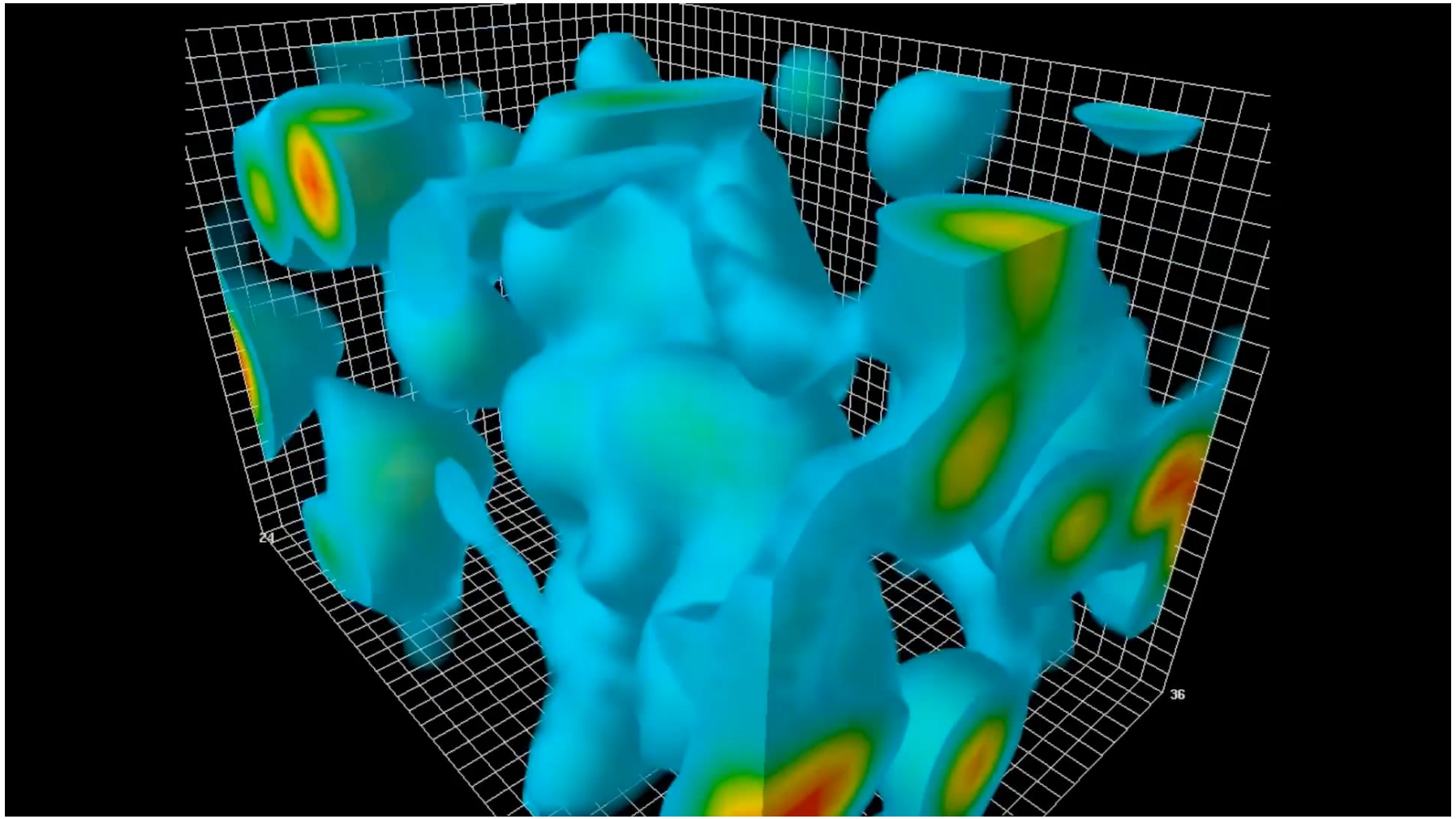
Particles



IGM: 1 particle / meter^3
Galaxy: 1 particle / cc
GMC: 1000 / cc
GMC Cores: 10^6 / cc



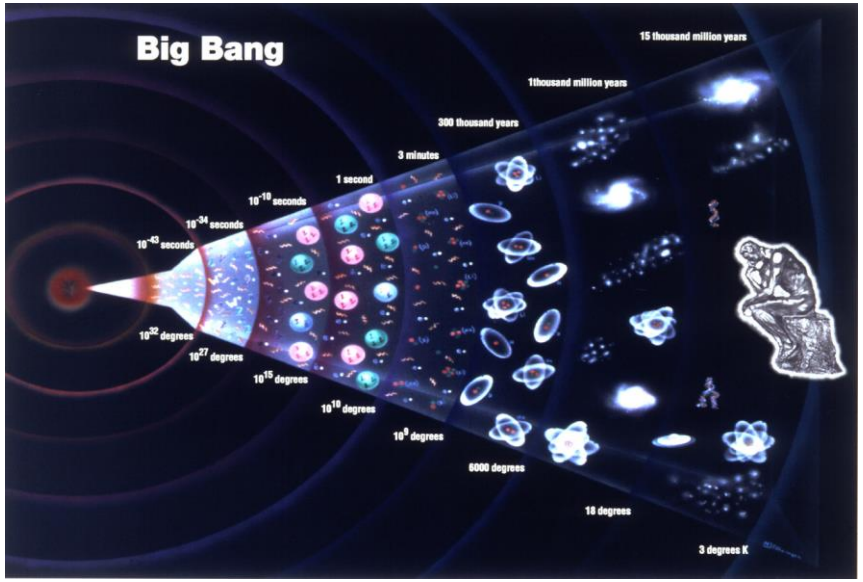
“Quantum Fluctuations” – Chromodynamics or something



Zero-Energy Universe

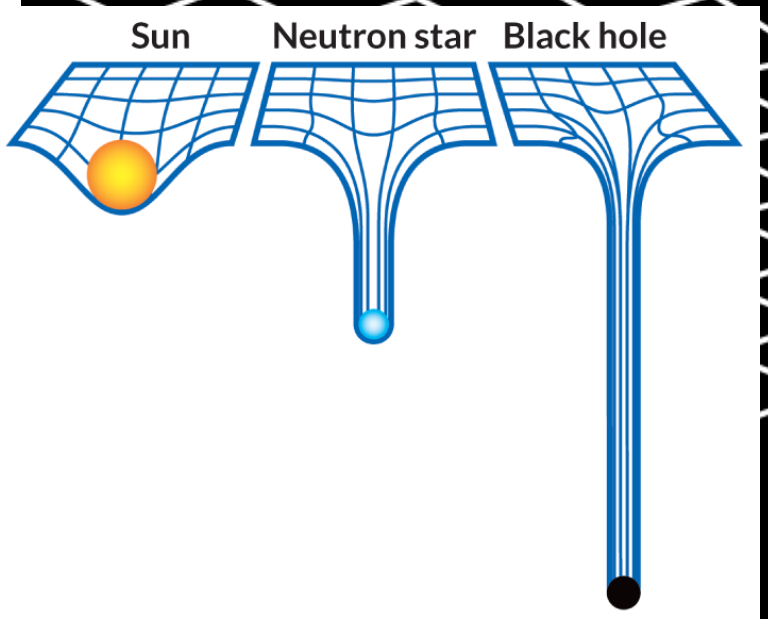
- Postulated in 1973
- Equal amount of positive-energy matter and negative-energy space/gravity

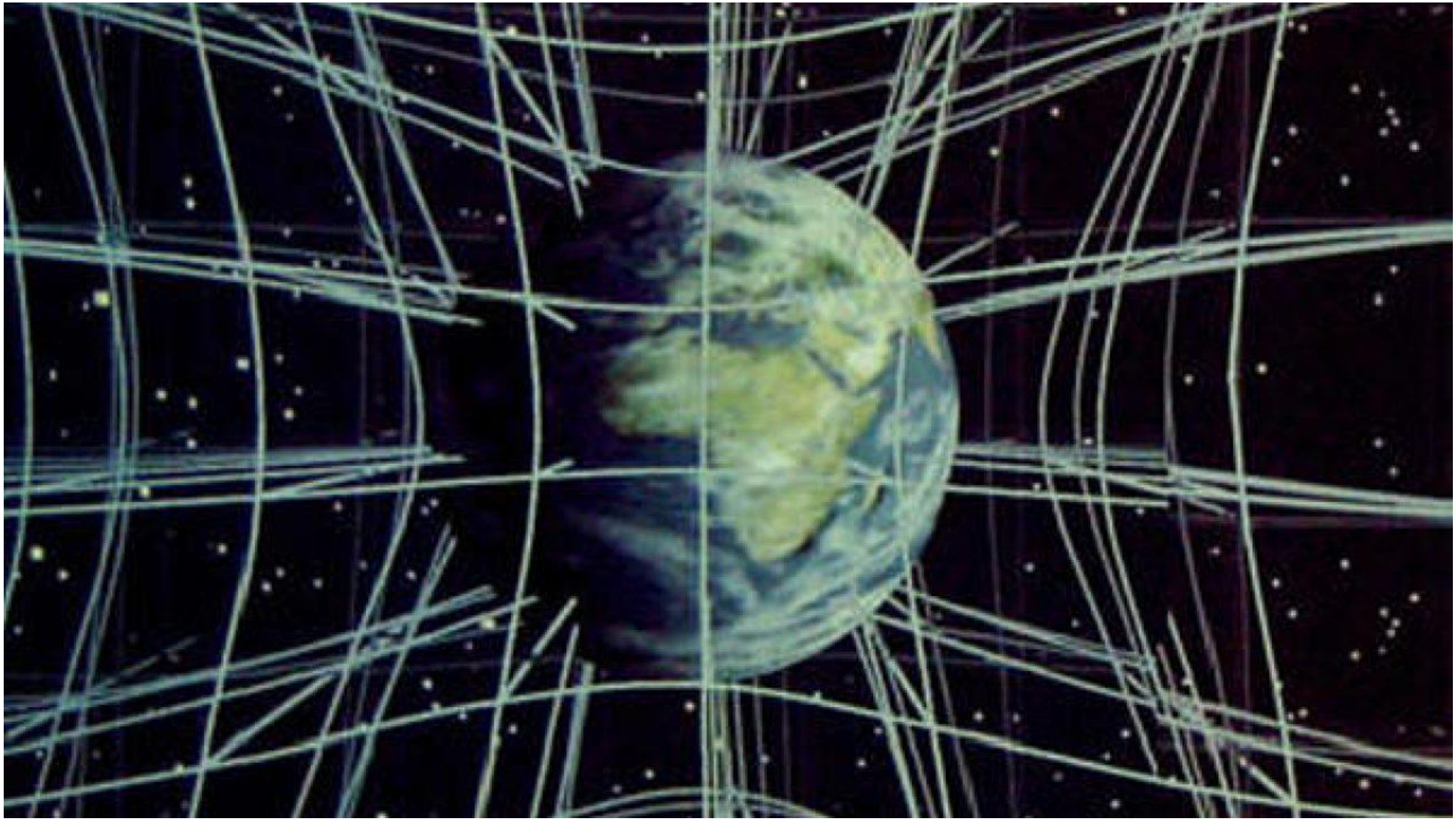
- Whole universe might be a "quantum fluctuation"
  - Source of the big bang
- Could explain "flatness" of universe"

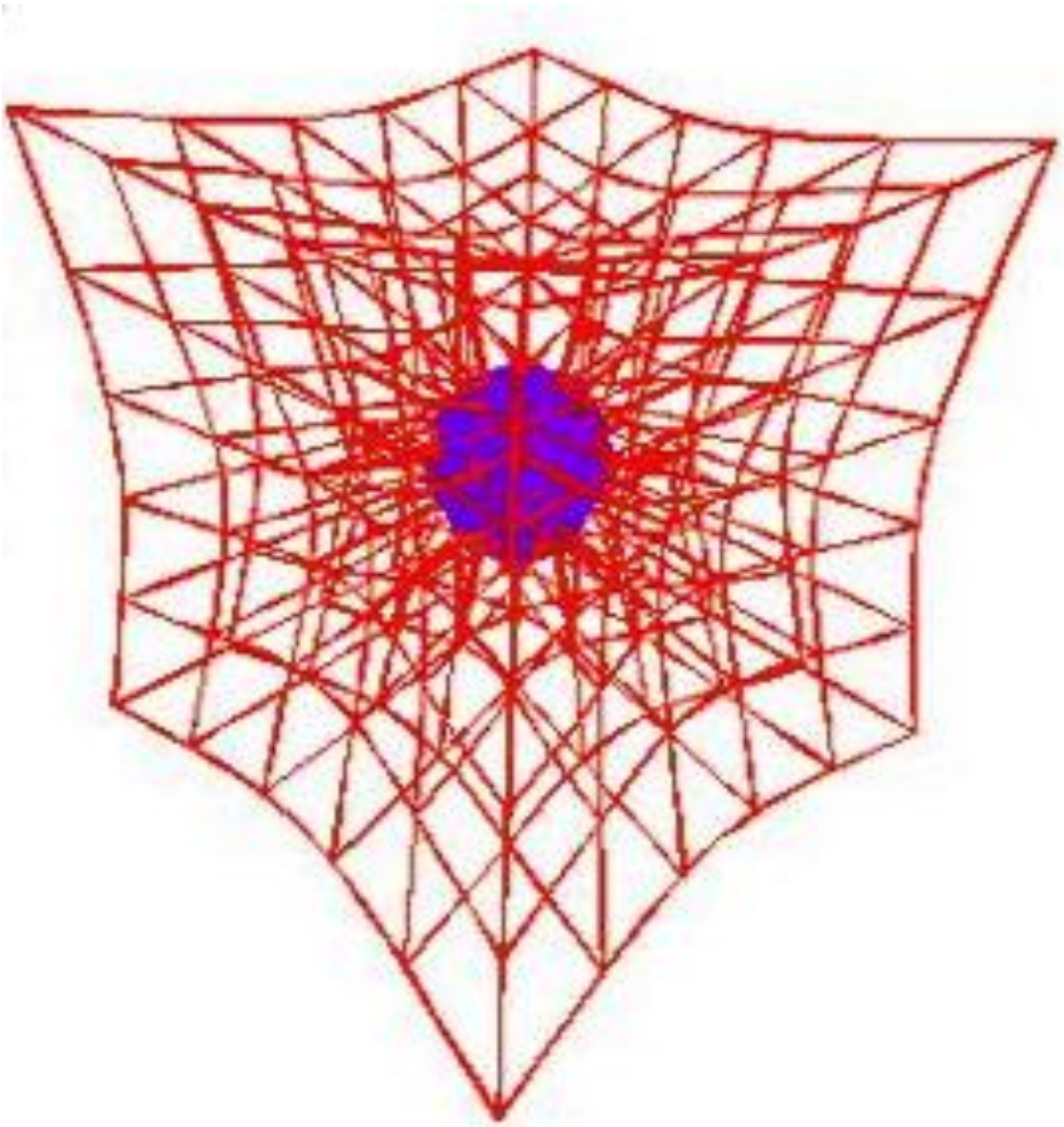


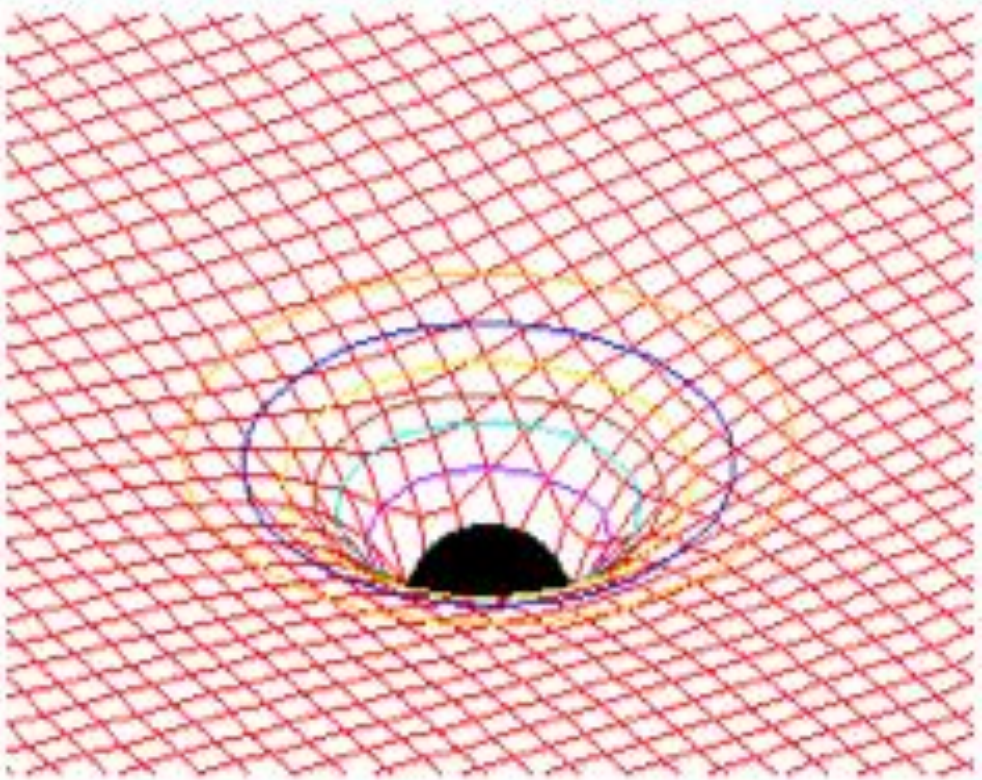
- Idea: Spacetime contains energy, and is a part of "empty space"

SPACE IS AN "OBJECT"!

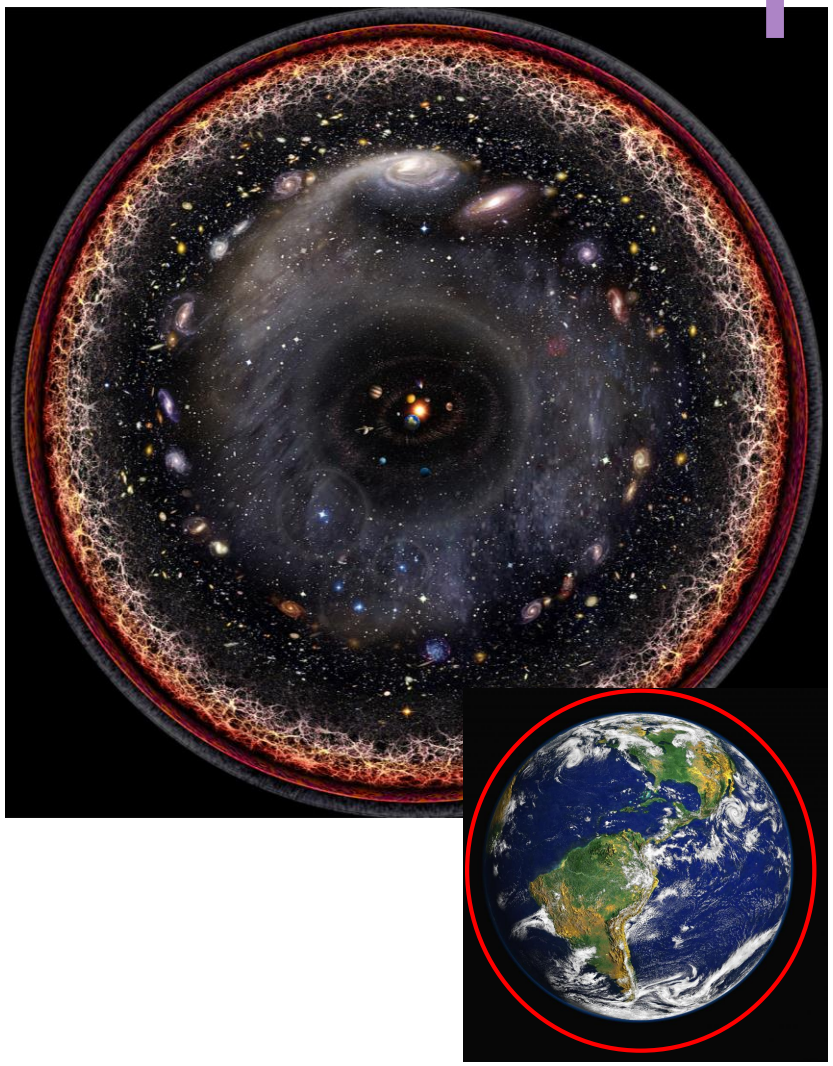






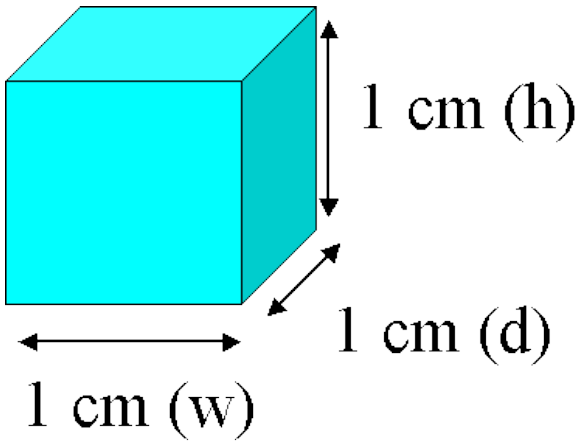


Space is Full



>Space is an object, filled with:

- (Magnetic) Fields
- Photons
- Cosmic Rays
- QCD Nonsense
- Hydrogen ("Stuff")



>For Matter: When you zoom out,
you also have to increase the size of your handful.

>There is way more stuff in space than on Earth.

Extra Stuff – Graduate Admissions

- Don't explain the details of your research – they don't really care
- Do include a few extra-curriculars. It counts for a lot!
- A grit story is great to have too.
- Letters of Rec are kind of just a box to check
- Make sure to say
  - Why you want to go to grad school at all
  - Why you want to go to this particular grad school