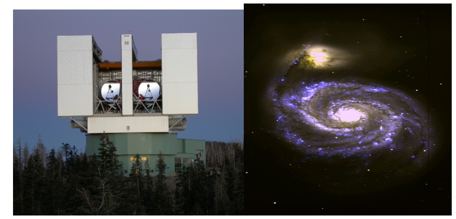
بسم الله الرحمن الرحيم

THE OHIO STATE UNIVERSITY



"STARS"

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- Adjunct Professor, Cairo University, Egypt

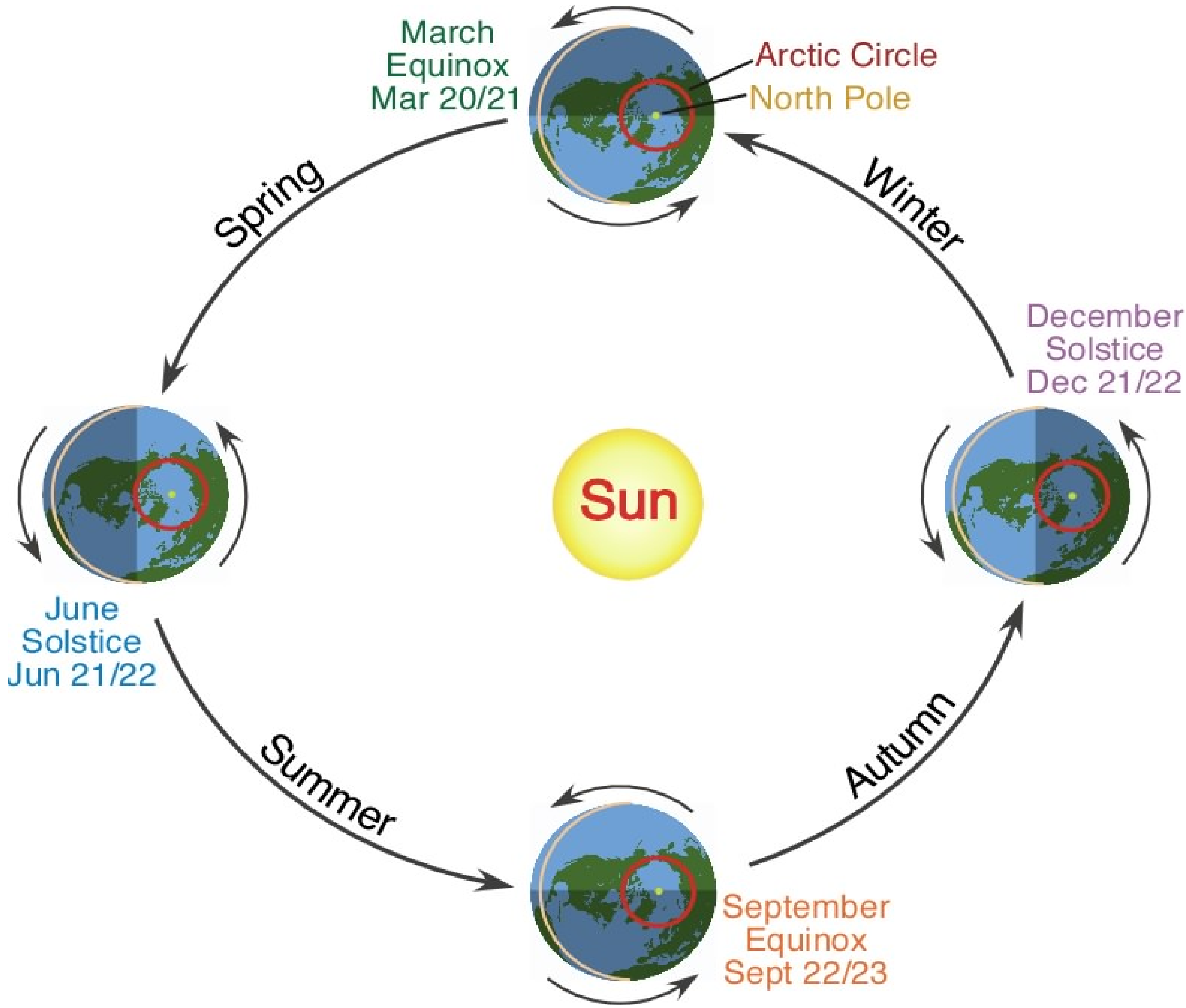
"BIBHA ALL-GIRLS ASTRONOMY WORKSHOP 2021"

International Astronomical Union (IAU)
National Outreach Coordinator (NOC)
BANGLADESH

BAS
Bangladesh Astronomical Society

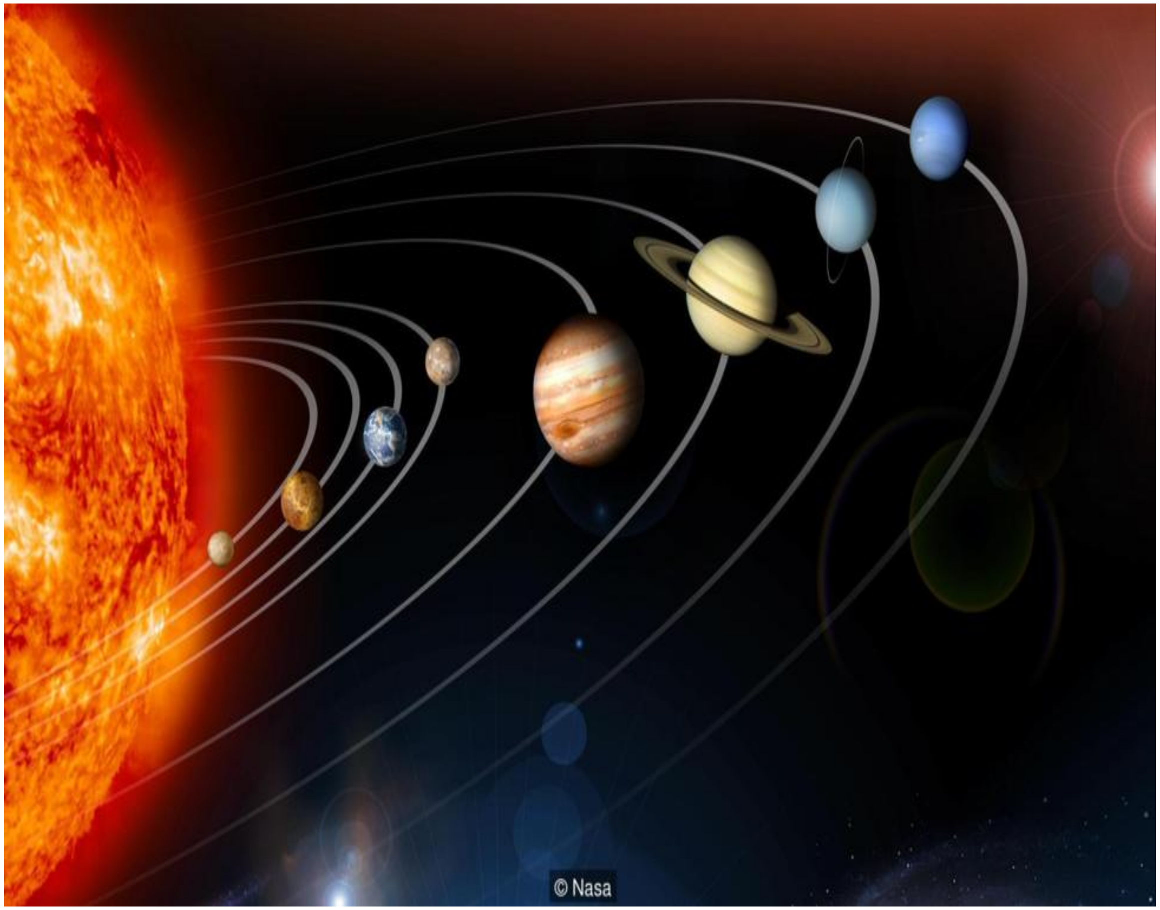
Dhaka, Bangladesh
Feb 11-13, 2021

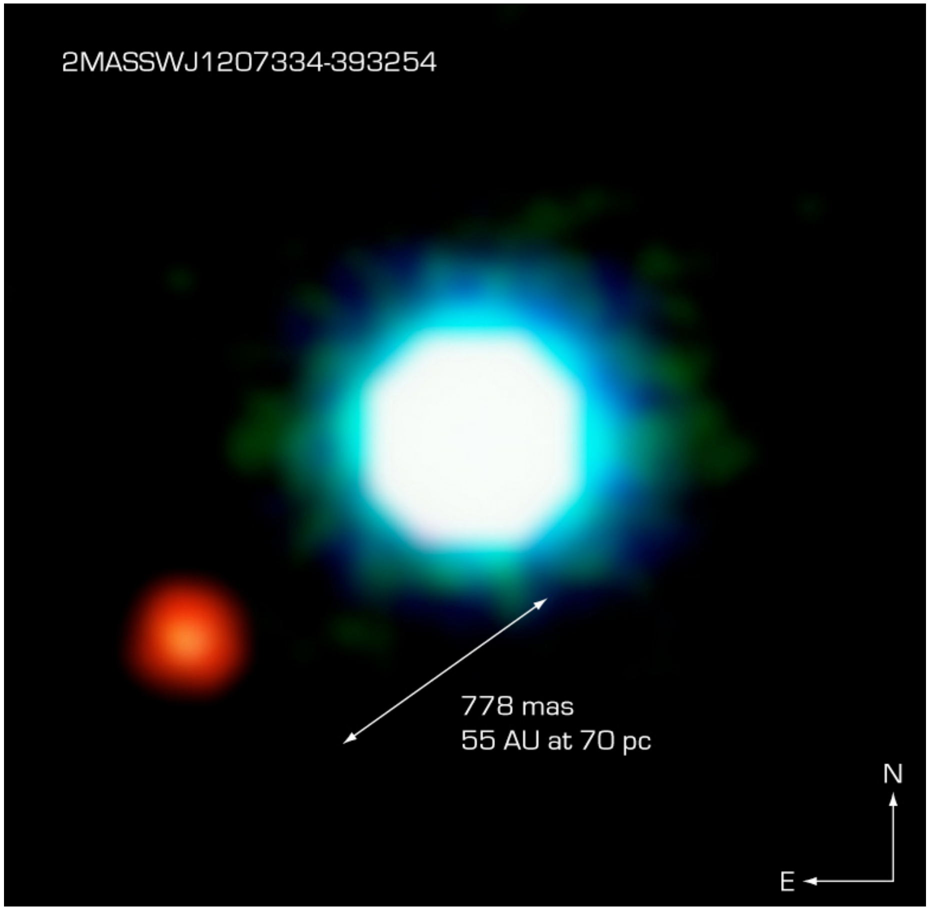
The SUN, Our STAR



- Sun is the source of energy for our Earth, its planet
  - It is the standard for studying other stars

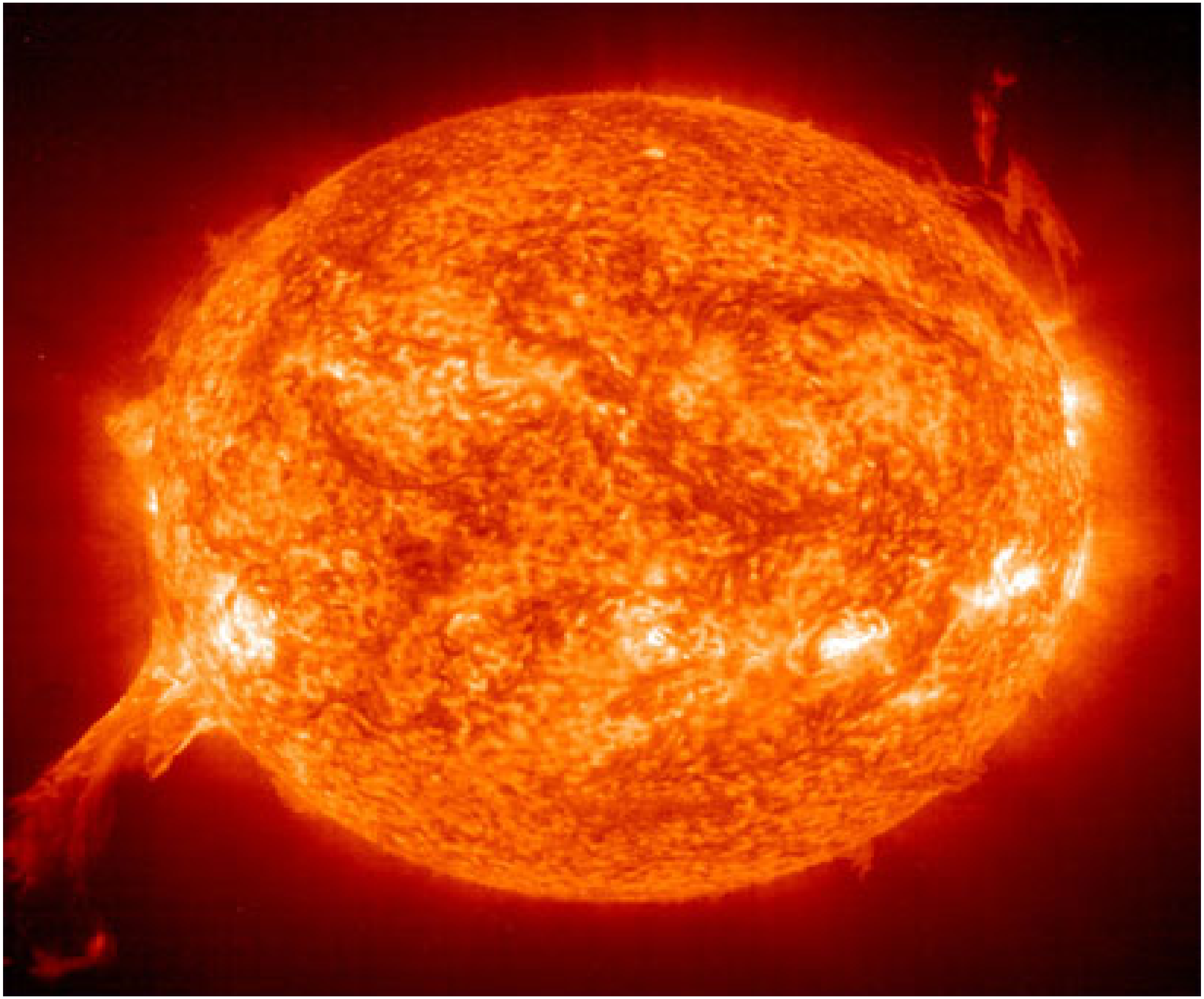
SUN: 110 x Diameter of the Earth





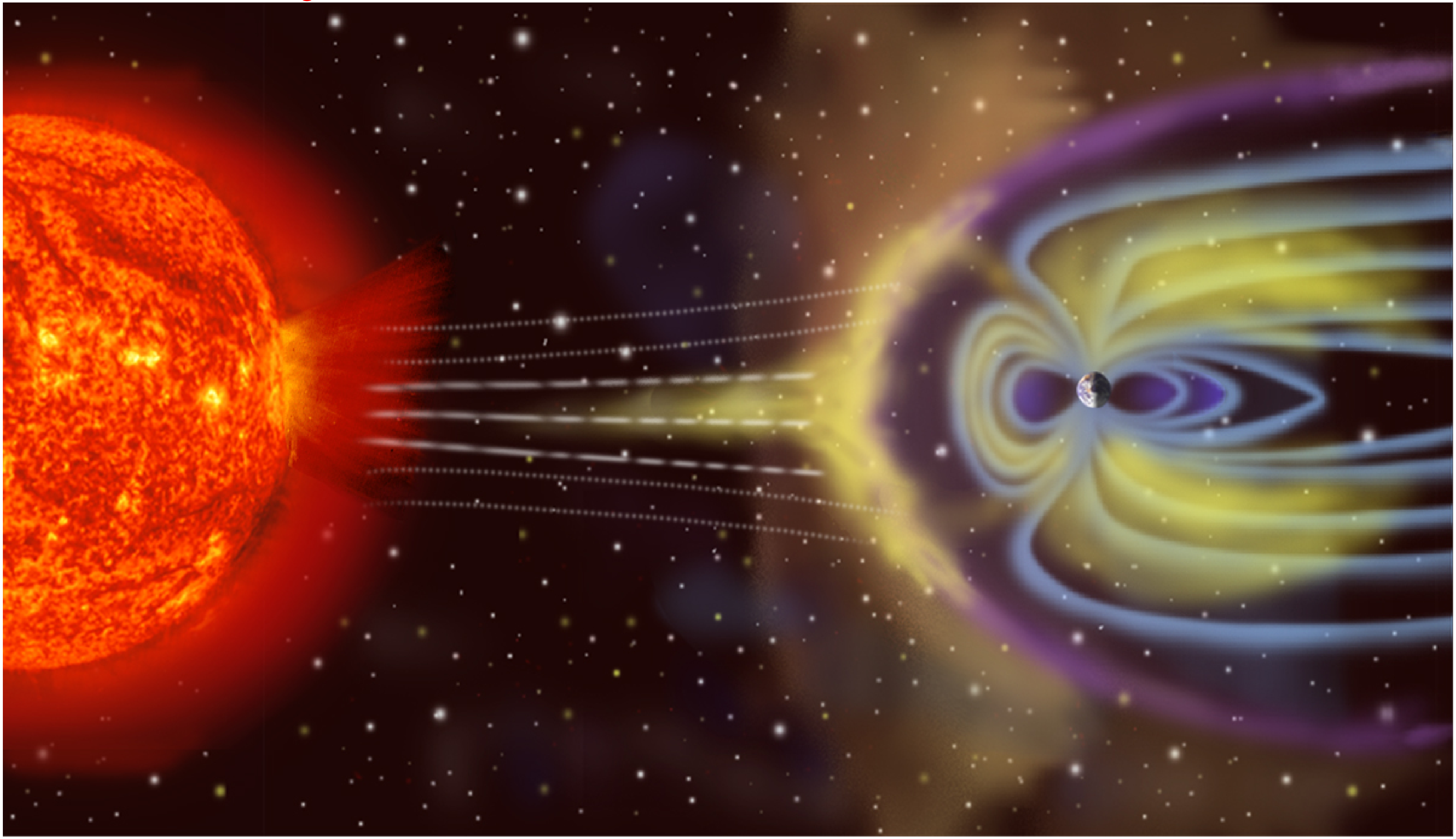
- L: Solar planets: Planets around our sun
- R: Exoplanets: Planets around a star except the sun - typically around cool red dwarfs
- The 1st exoplanet 2M120b-ESO2004, by HARPS in 2004
- Sun: 8 planets and a number of dwarf planets around it

SUN - The ”unQuiet” Star (Observed by space observatory SOHO)



- Sun has a 11 years cycle of minimum to maximum ACTIVITY, when its magnetic field flips between North and South
- Eruptions with explosions ejecting large amount of particles & radiation

Solar Ejections - Radiation & Particles

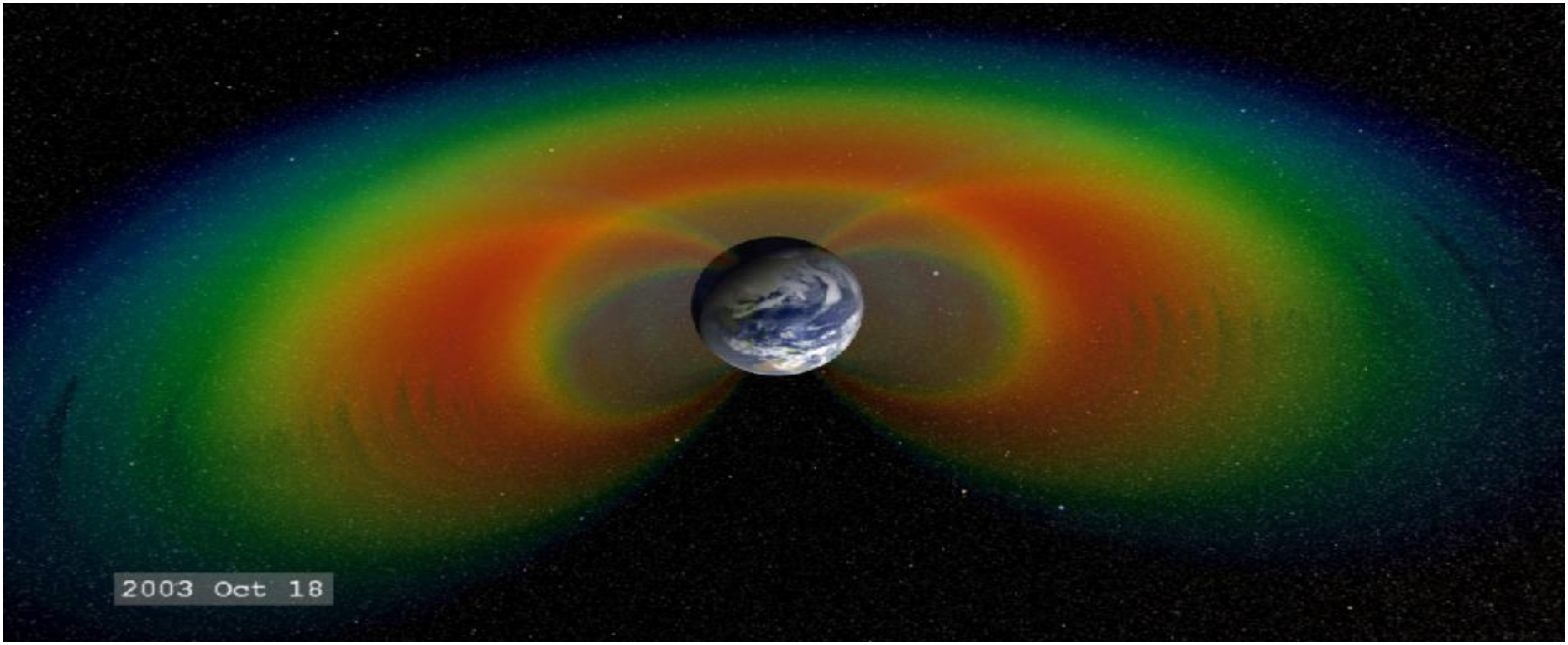


• Solar storms ejects bursts of electrons, protons, & heavy ions accelerated by massive explosions inside

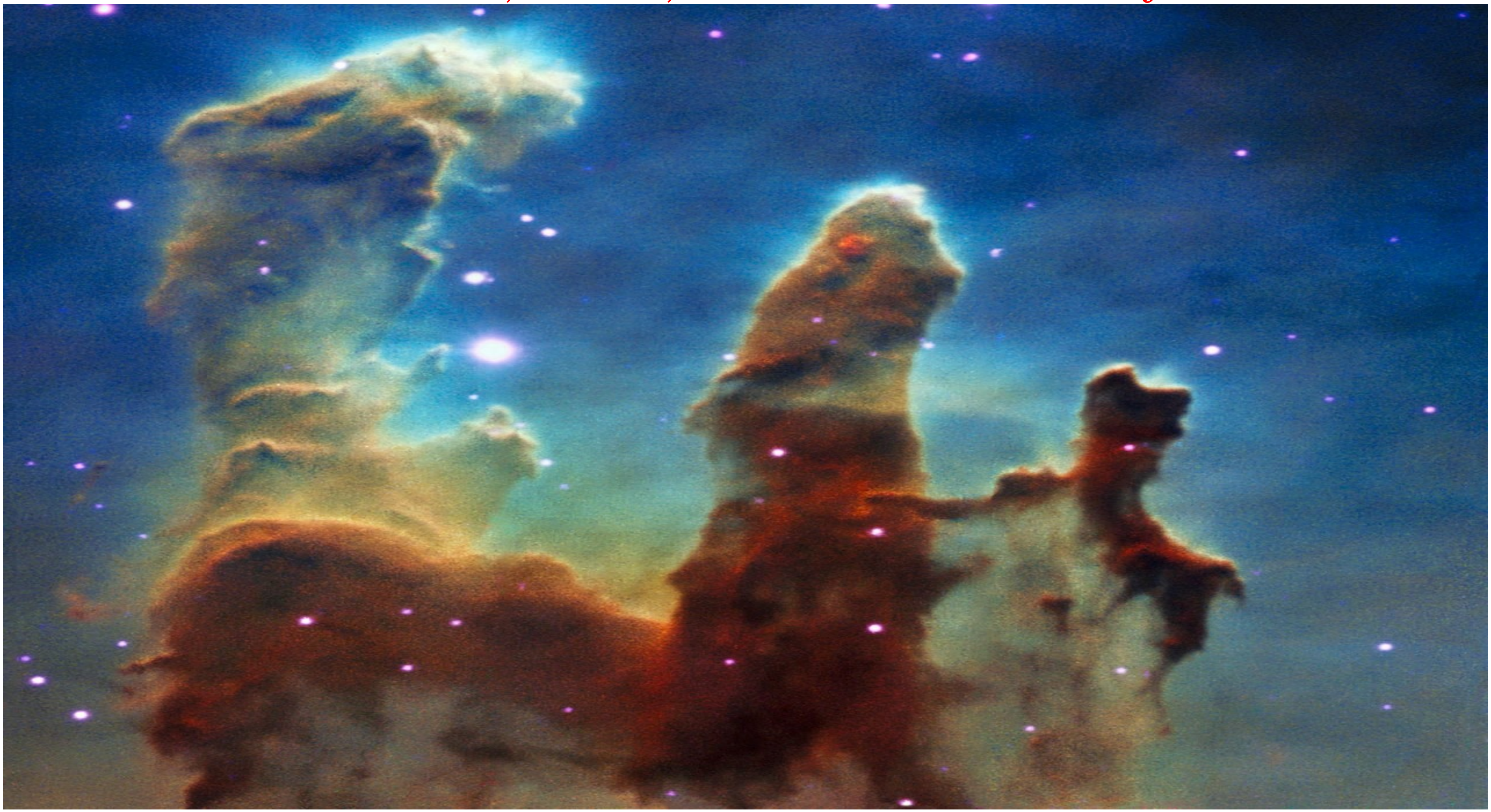
• Our Earth's atmosphere and magnetic field protects us from these massive bursts of particles and radiation by reflections, absorption, and captures

• For example, magnetic field capture charged particles, ozone layer blocks most ultraviolet, X-rays and Gamma rays • Most dangerous particles are ions which can

VAN ALLEN BELT FROM HALLOWEEN SOLAR STORM, AURORA

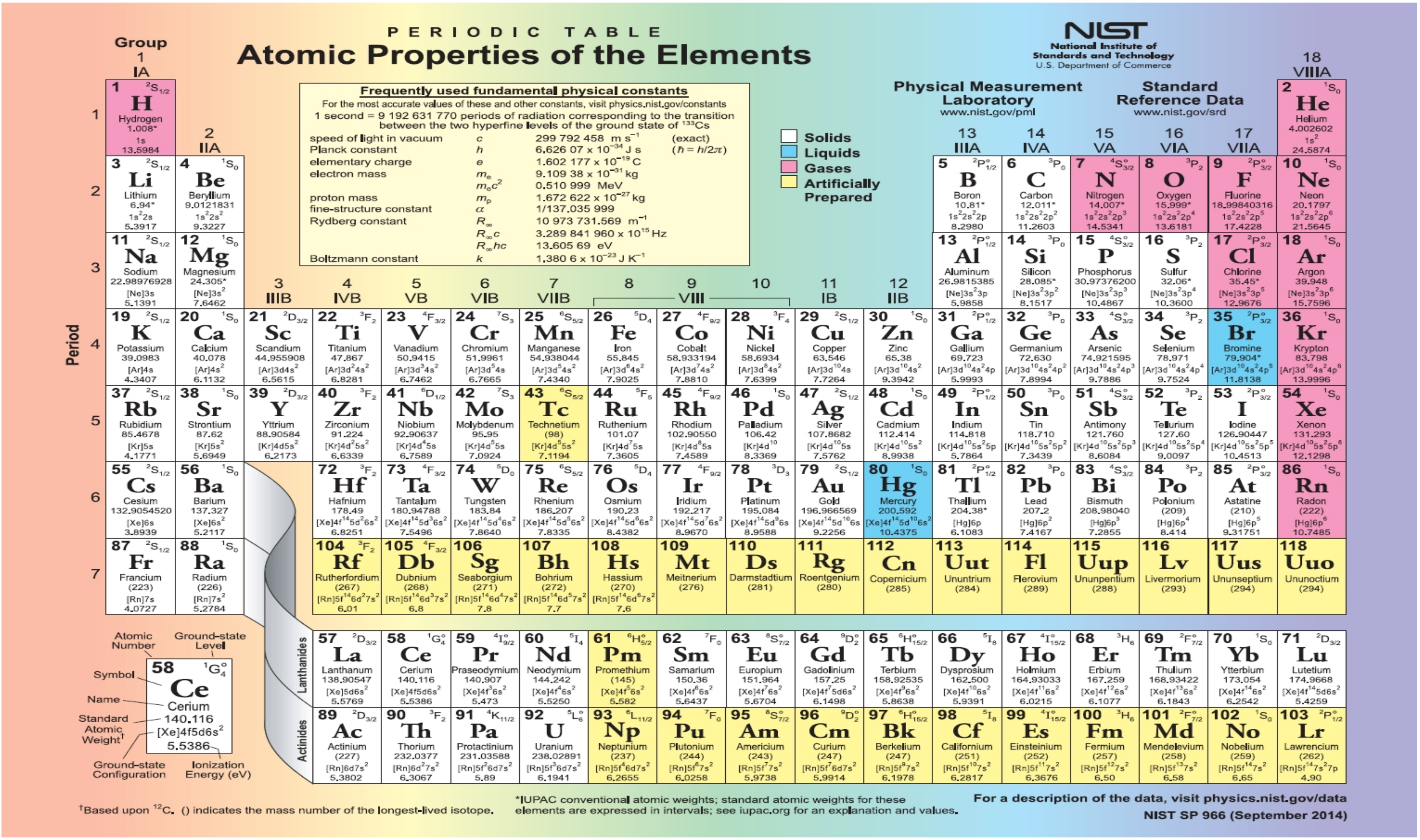


STARS: BORN, LIVE, DIE - Has a Life Cylce



- Atoms, molecules, dust traveling in space slowly accumutaltes due to gravity - form gaseous nebula
- Concentrated gas and dust collapse due to gravity. A star starts to form and then starts to shine. They usually form in groups
- It takes about a million year to from a star
- Pillars of Creation in Eagle Nebula, stellar birth place

FORMATION OF ELEMENTS VIA NUCLEAR FUSION AT CENTER - generates radiation that travels out - makes the star shine



- 118 Elements: Gases (pink), Solids (white), Liquids (blue) A lab generated yellow element is replaced with astrophysical observation
- Elements are created through nuclear fusion. It starts with creating He from 2 H atoms. As plasma density and T increase in the stellar core, Li, C, N, O etc are created, and the process continues up to Fe

"OUR COSMIC SELVES": (NY Times, April 13, 2015)

Astronomer Prof. Carl Segan promoted: "We are made of star dusts"

- Science continues to show thatd life on Earth is intimately

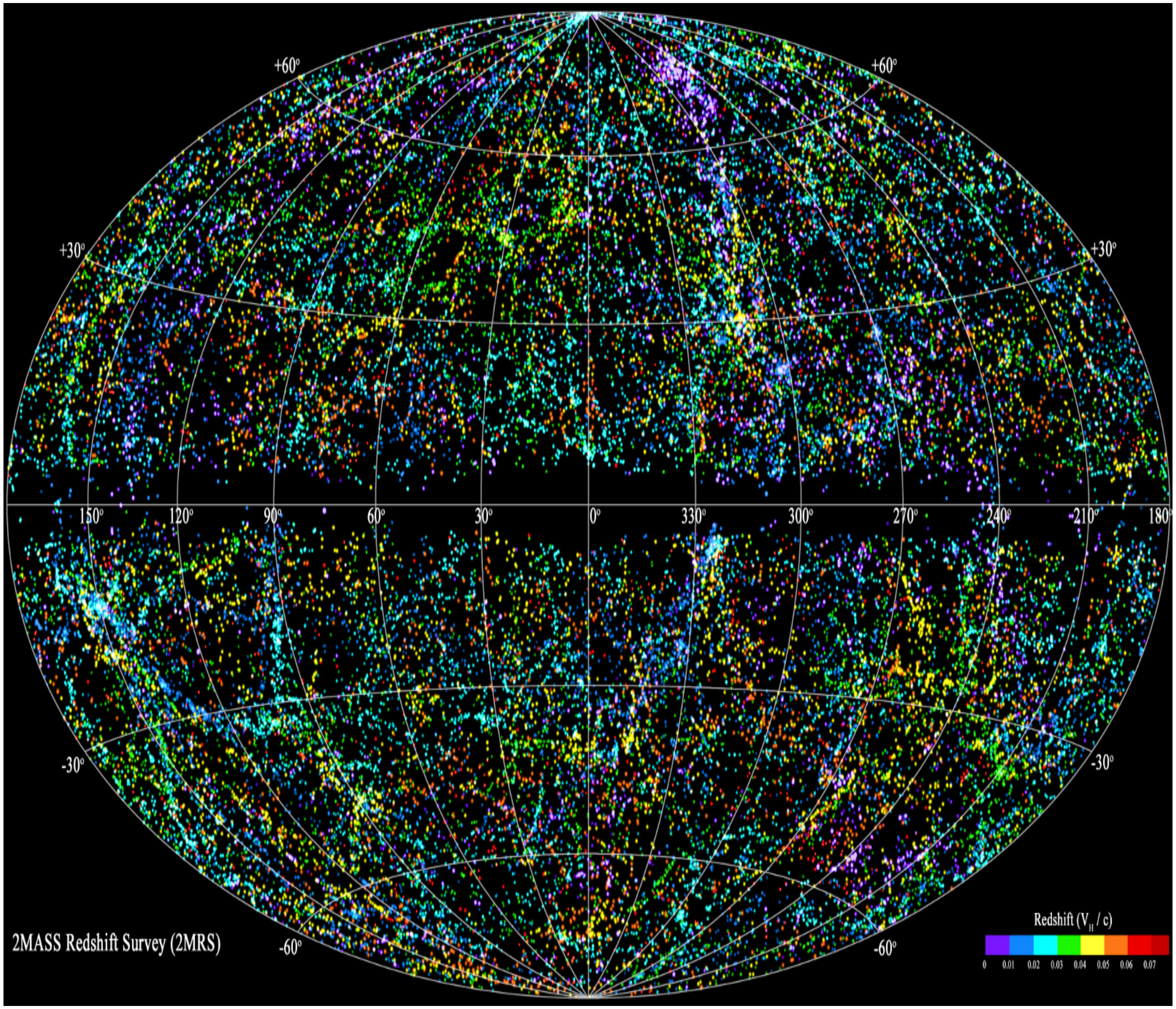
The spiral galaxy NGC 3521 is located around 26 million light years away in the constellation Leo, with enormous amounts of surrounding dust and stray stars glowing far out from its disk.

Gas + stars form Galaxy, MILKY WAY, Our Galaxy!

- **Milky Way: 200-400 billion stars, including the Sun**
- **Milky way - spherical . The Sun is near the edge of it**

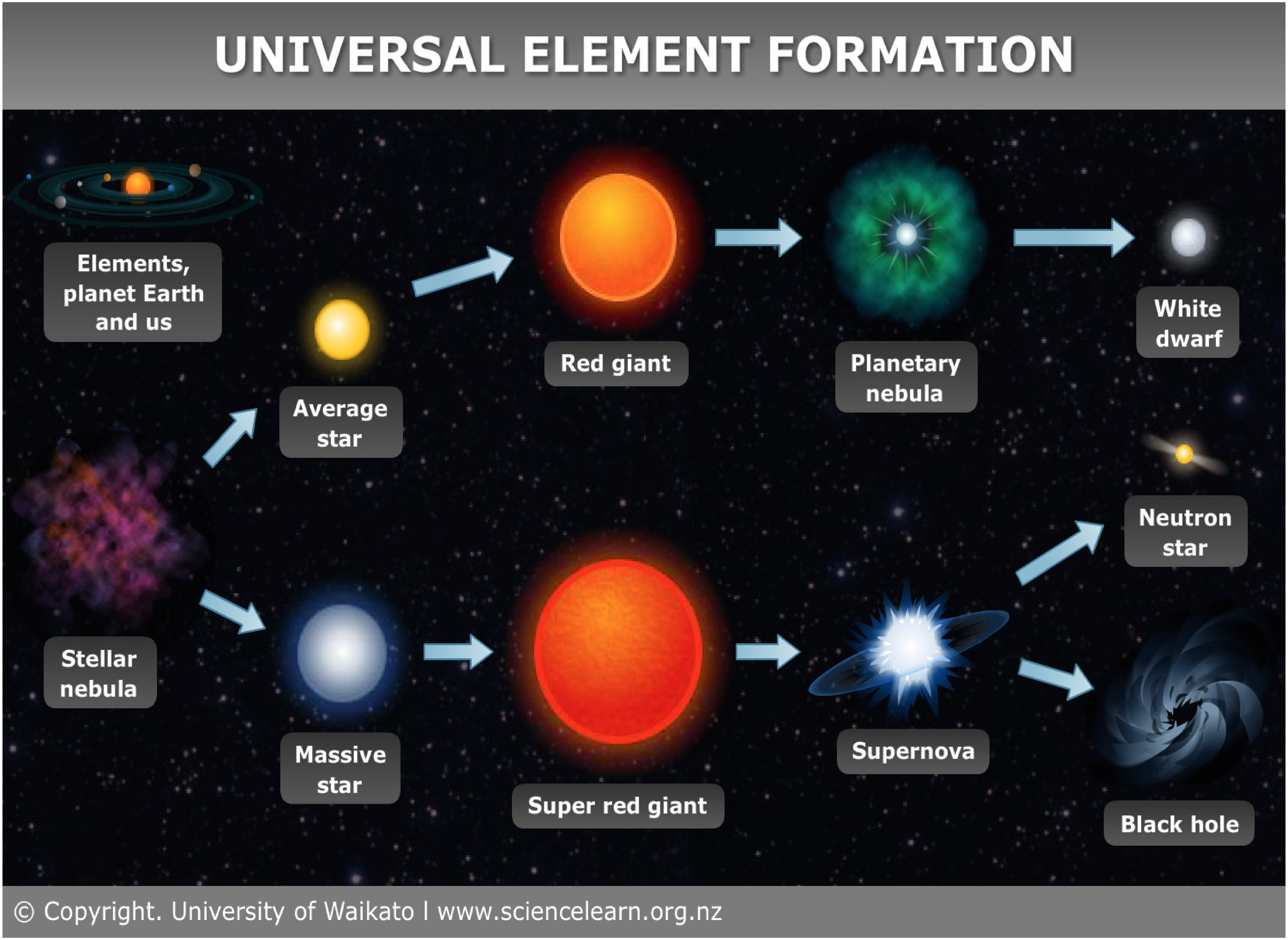
UNIVERSE through RADIATION:

Most Complete 3D Map of the universe (Created: By 2MASS - 2-Micron All Sky Survey over 3 decades)

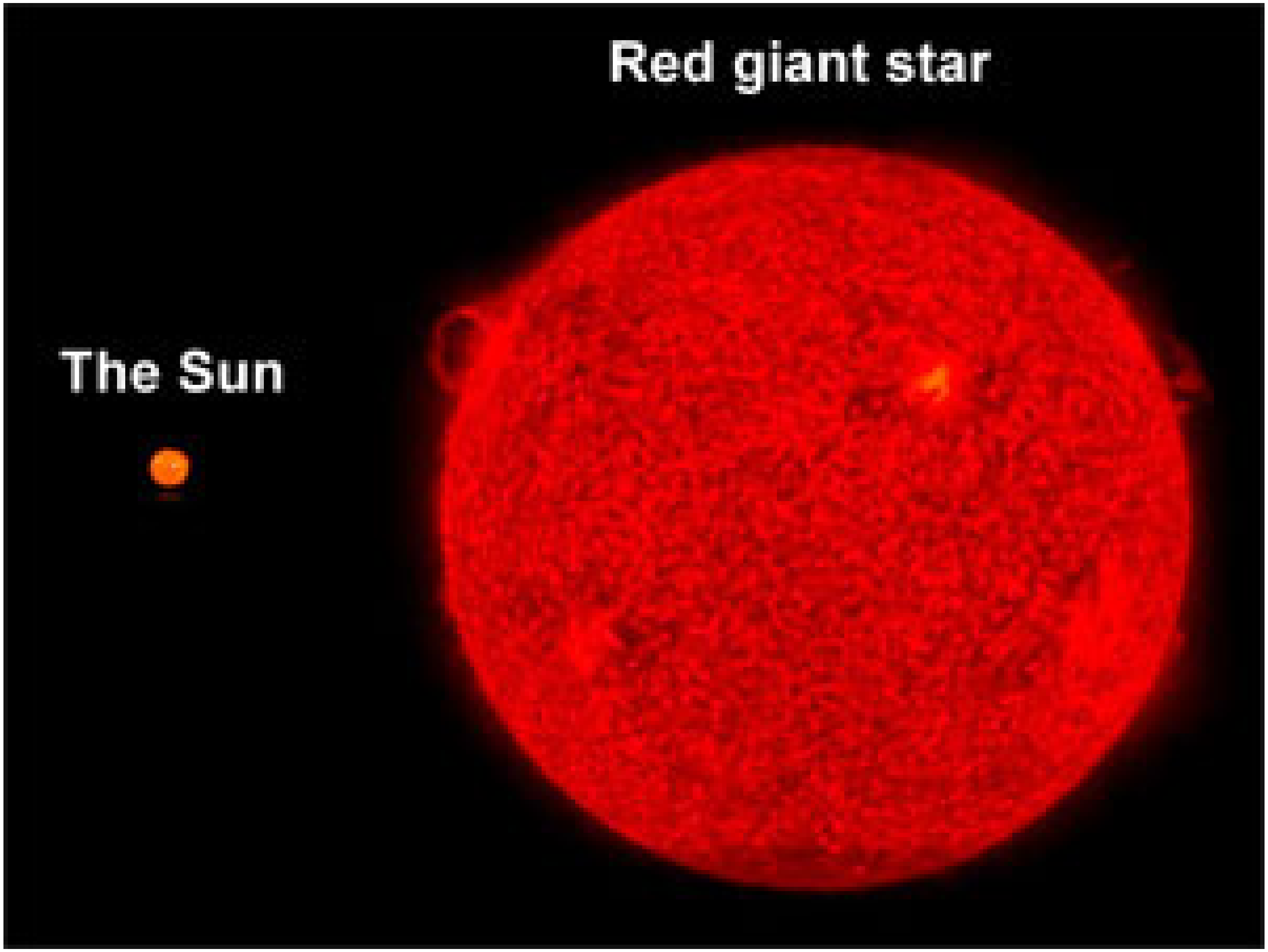


- Includes 43,000 galaxies extended over 380 million light years y
- Redshifts, or measurements of galaxy distances, were added
- Missing black band in the middle because of invisibility behind our Milky Way

LIFE CYCLES OF AVERAGE AND MASSIVE STARS

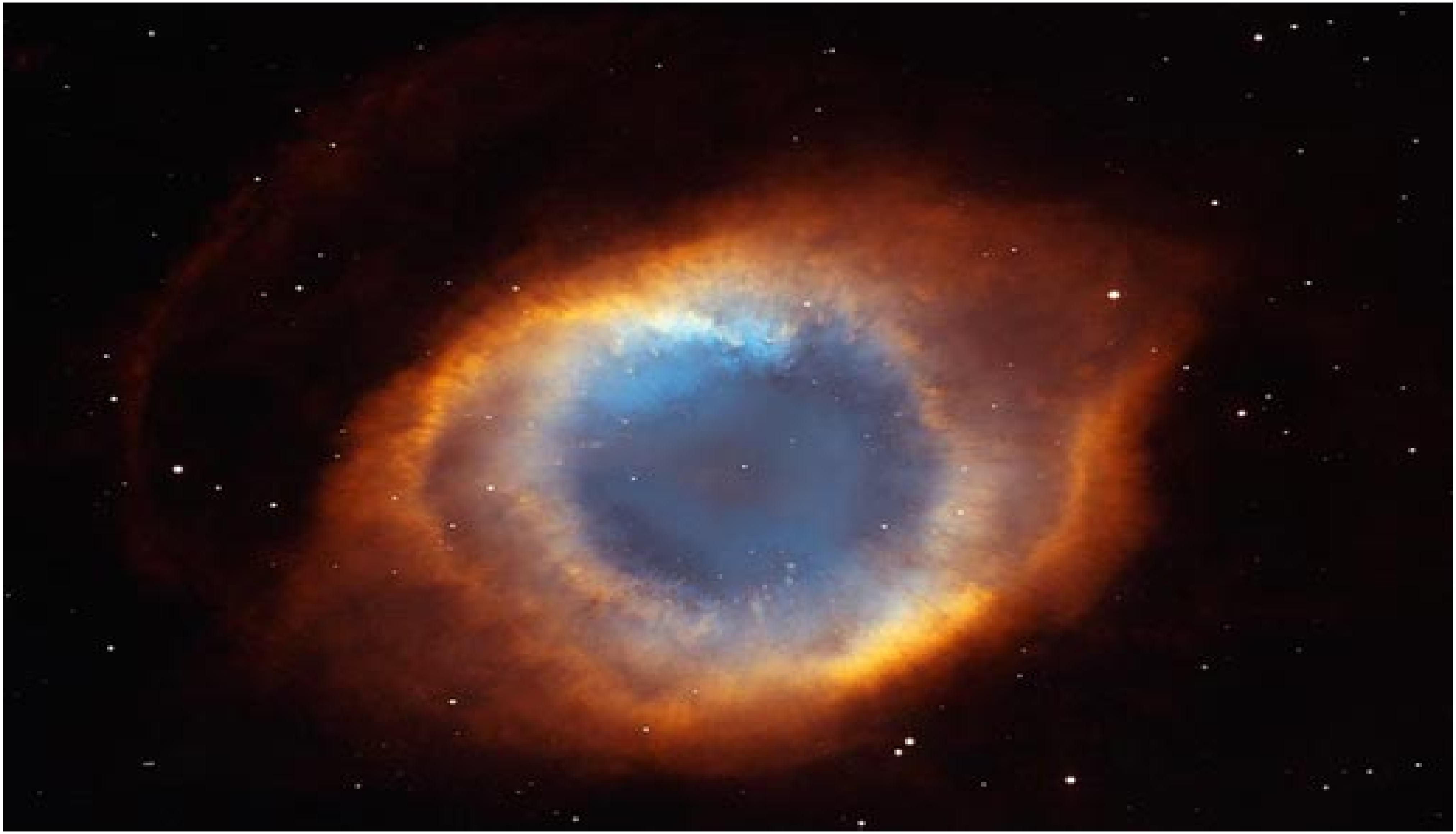


FATE OF OUR SUN IN 6-7 BYR: RED GIANT



- Red Giant is a dying expanded star with H fuel gone.
- The heat and radiation will put materials out to form a red giant. The outer atmosphere is inflated and tenuous, making the radius immense. Our earth will be engulfed by the Sun.

PLANETARY NEBULA - Endpoint of a Star [PNe K 4-55 below]

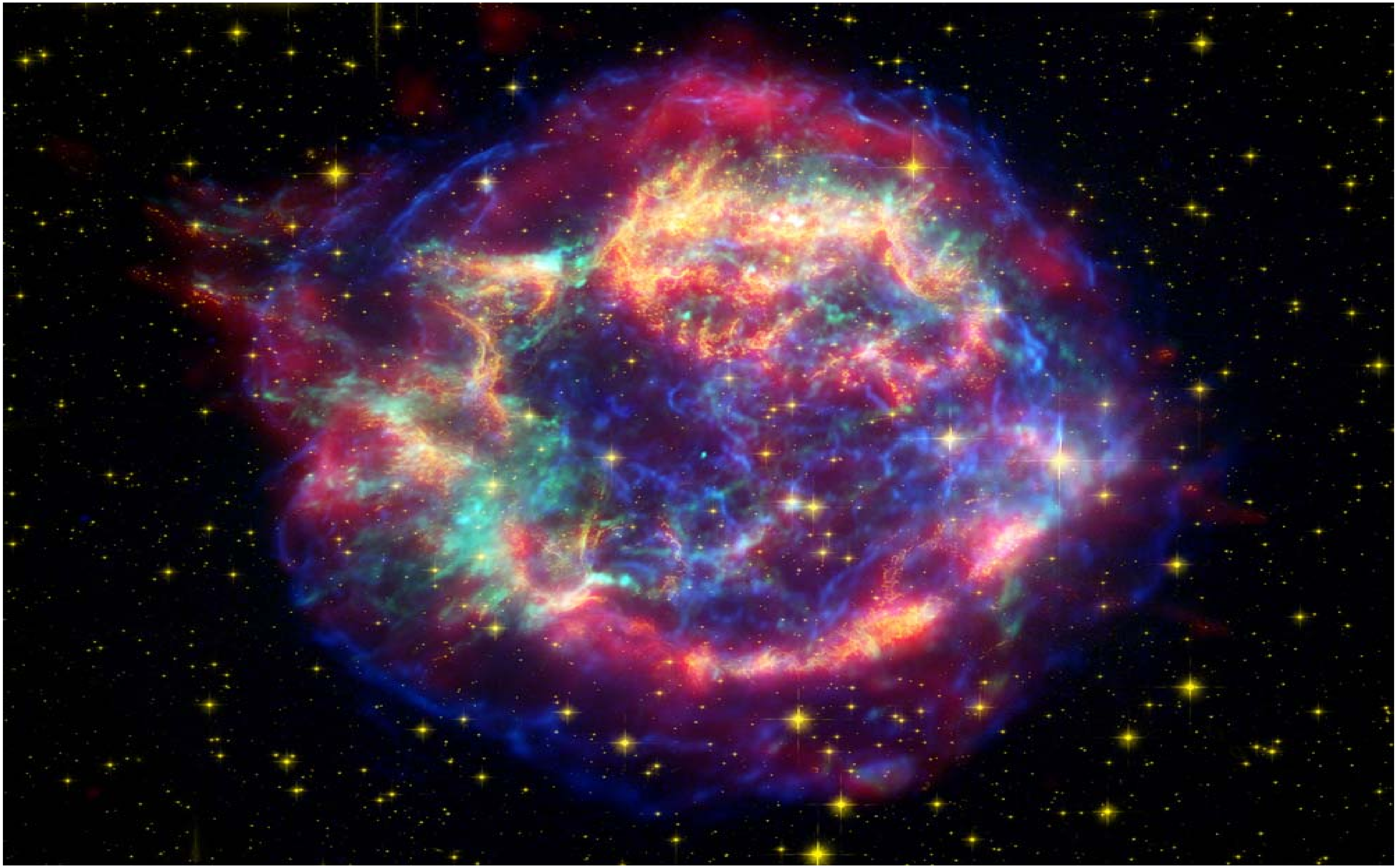


- Red giant will slowly become planetary nebulae
- Condensed central star: very high T $\sim$ 100,000 K ($>>$ T $\leq$ 40,000 K - typical star). Envelope: thin gas radiatively ejected & illuminated by central star radiation: red (N), blue (O). Lines of low ionization states - low ρ & low T

End of life: WHITE DWARF - Ex: Dianmond white dwarf 2014

- "Astronomers discover Earth-sized diamond-encrusted white dwarf" 2014. Its so old that it has crystallized into a Earth-sized diamond
- A white dwarf is very dense: its mass is comparable to that of the Sun, while its volume is comparable to that of Earth.
- Abour 98% stars will end up as white dwarfs
- Untimately they will be black dwarfs after loosing all energies

Creation of Heavy Elements: Supernova explosion, r-process

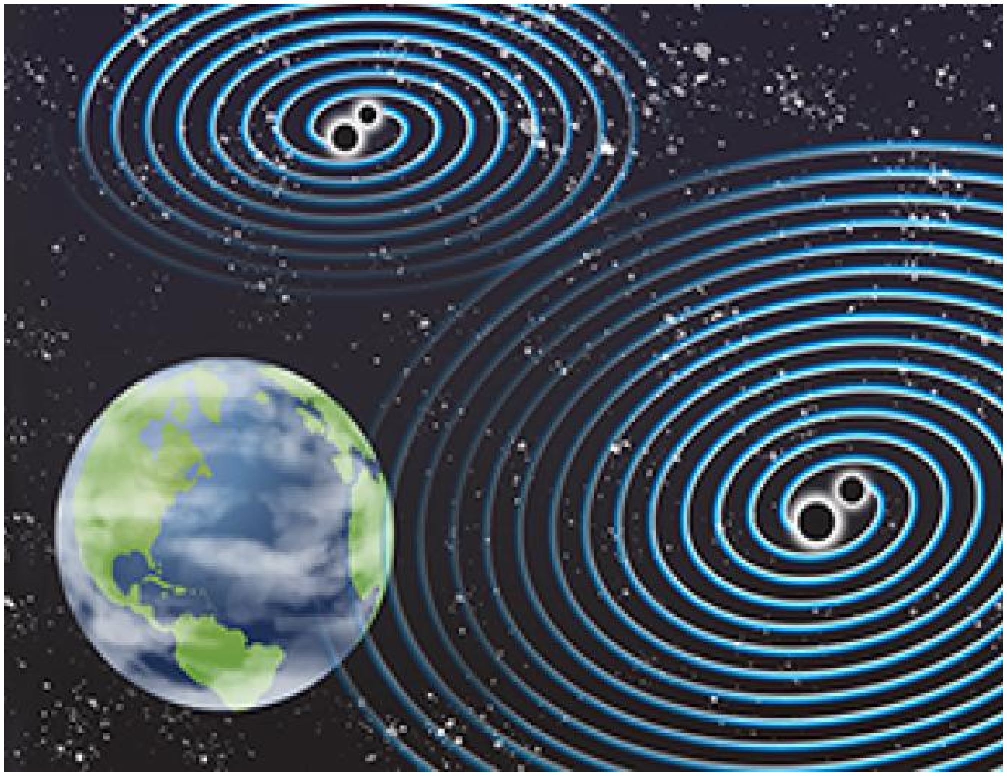


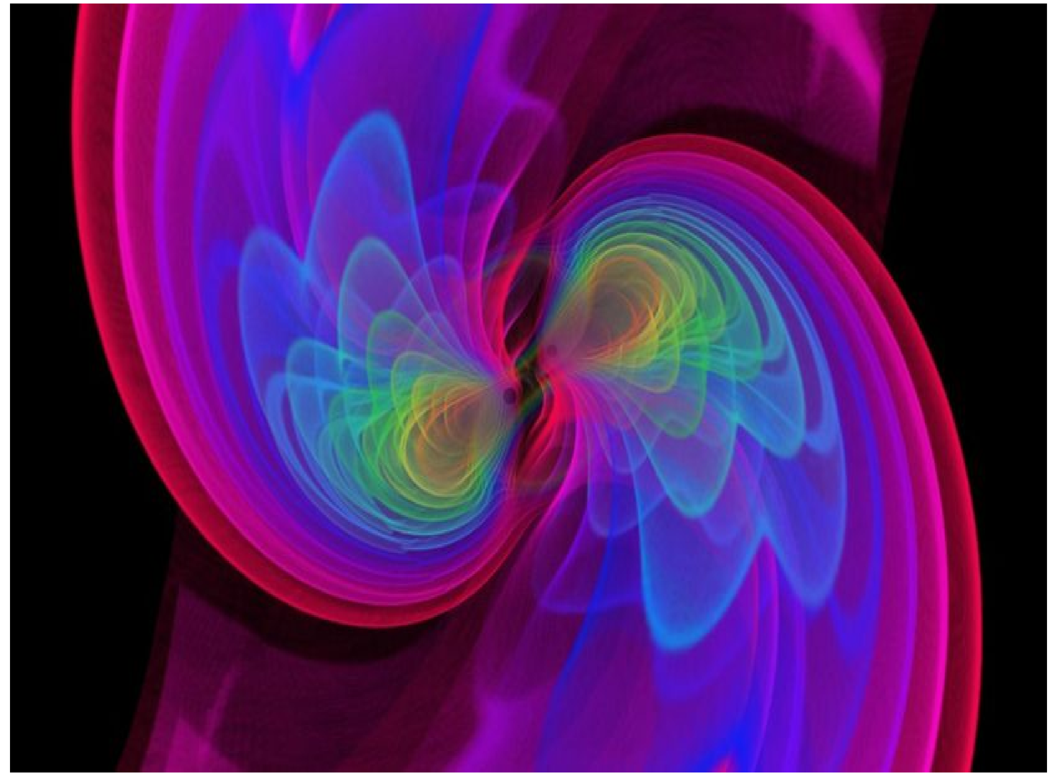
Supernova remnant Cassiopeia A: • Observation: Spitzer (Infrared - red), Hubble (Visible - yellow), Chandra (X-ray - green & blue)
• As a massive star collapses & expand, Heavier elements are created by r-process. New source of r-process: mergers of black holes, neutron stars - a kilonova event

NEUTRON STAR - At center of Crab Nebula

- **After supernova explosion strong gravity due to stellar mass, can cause electrons to combine with protons to form neutrons.**
- **The Crab Nebula, the result of a bright supernova explosion At its center is a super-dense neutron star, rotating once every 33 milliseconds, shooting out rotating lighthouse-like beams from radio waves to**

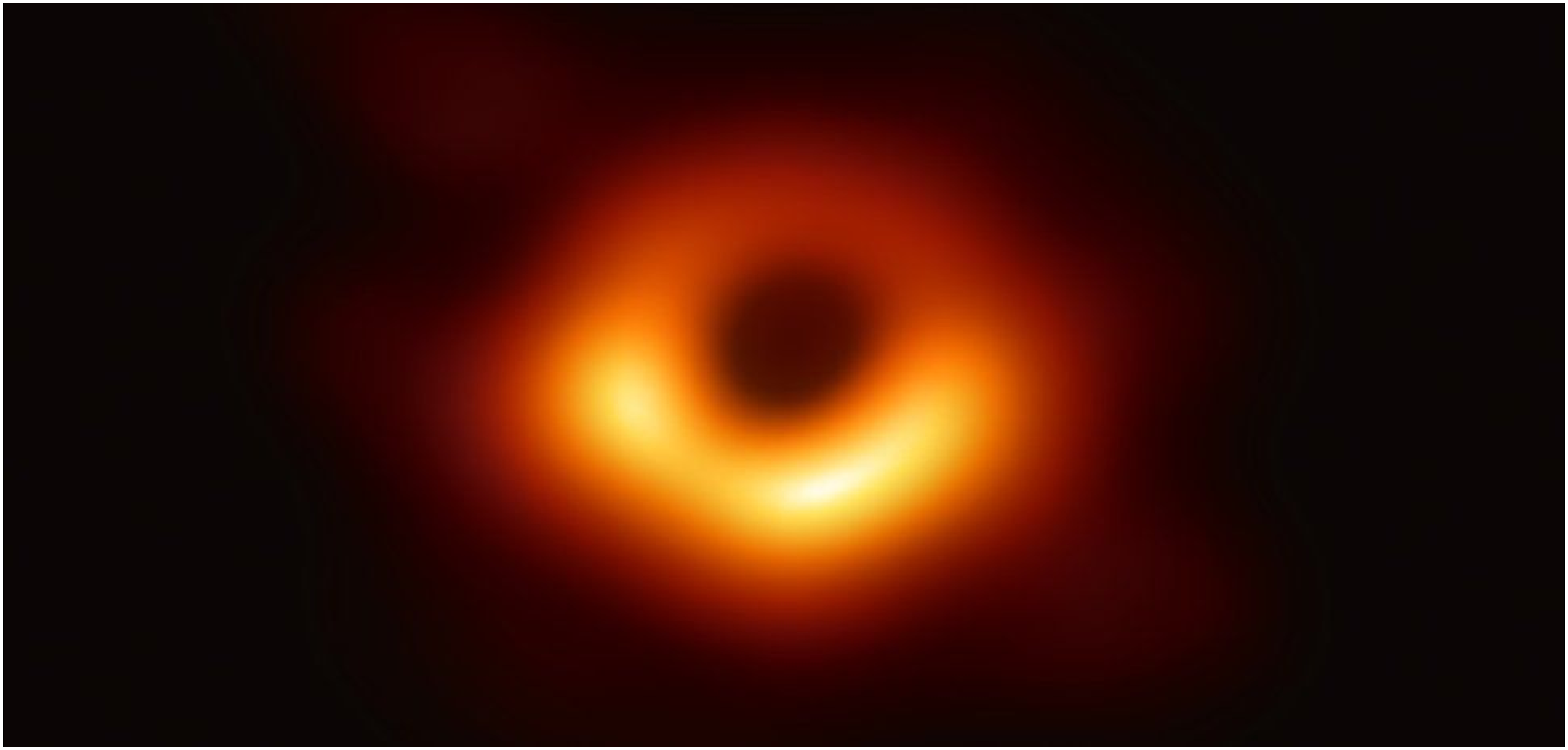
GRAVITATIONAL WAVES (GW) AND 3 LIGO SET-UPS





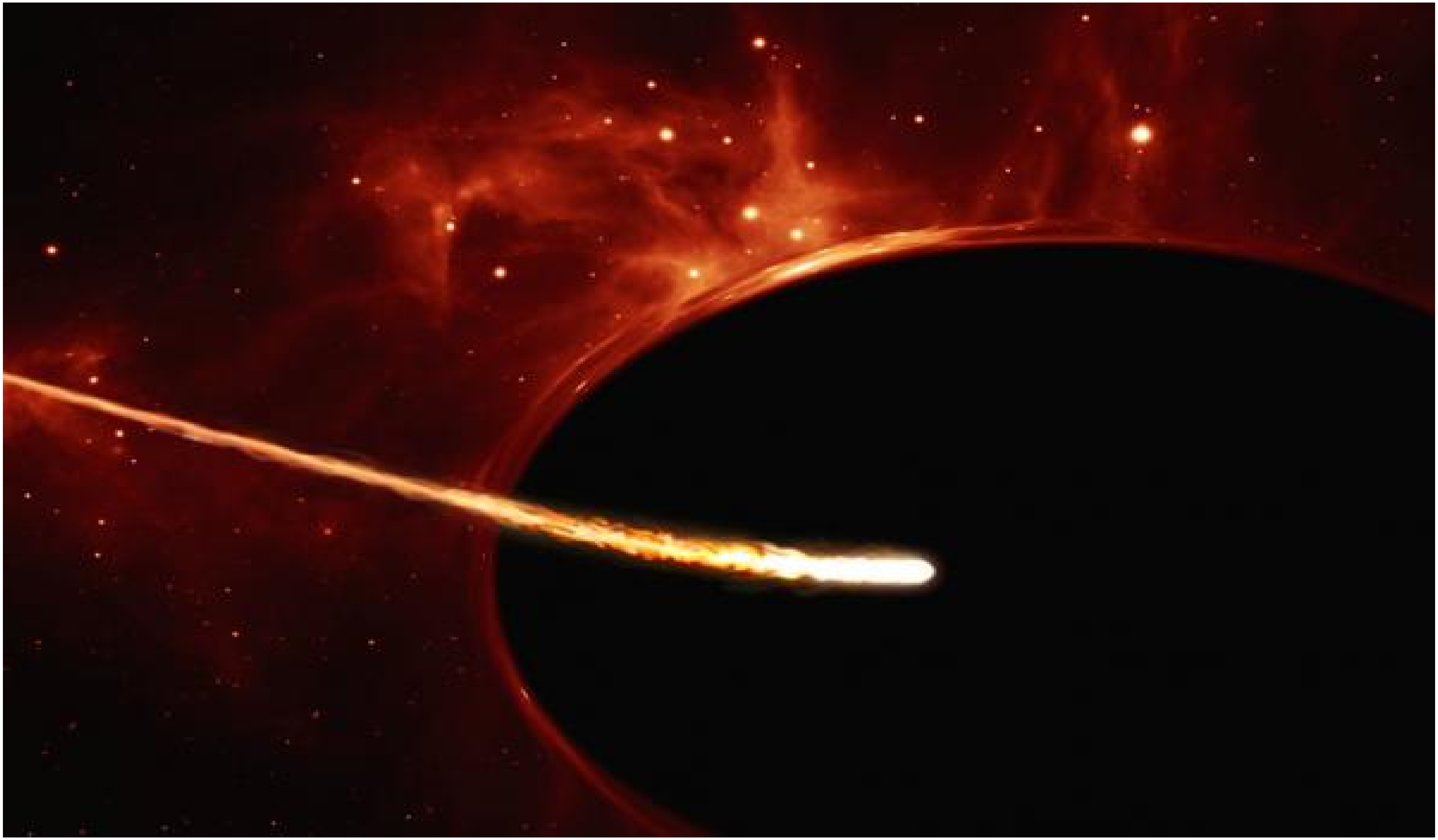
- **Einstein predicted that an accelerating or decelerating mass will generate gravitational waves which will travel at the speed of light. It is similar to that of a charged particle which gives out electromagnetic waves. However, the GWs are extremely weak to detect - very large radio waves. They will expand and contact the earth if they pass.**
- **Russian idea of using laser interference to detect small change by the GWs in 1960s - was implemented by Rainer Weiss in the LIGO set-up - first detection in 2015 after over 20 years - Nobel prize in 2017**
- **3 far-apaer set-ups: Hanford in Washingotn State, livingston in Luisiana, Pisa in Italy help to dtect the direction of GWs.**

First ever black hole image released, Apr 10, 2019



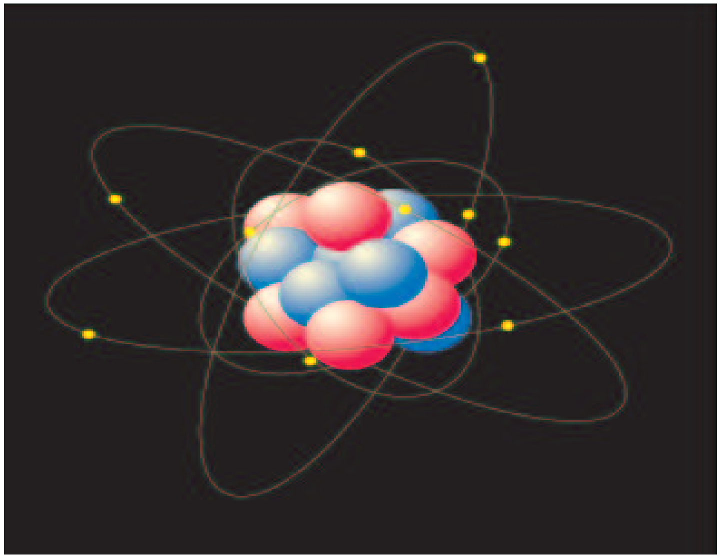
- The first ever image of a black hole, located in a distant galaxy, measures 40 Bkm across - 3M times the size of the Earth - and has been described as "a monster". It was composed from photographs by a network of eight "Event Horizon" telescopes across the world.
- The monster black hole in the center of our Milky Way galaxy: 4M time heavier than our Sun, tracked by the movement of 28 stars circling around it - Nobel prize in 2020

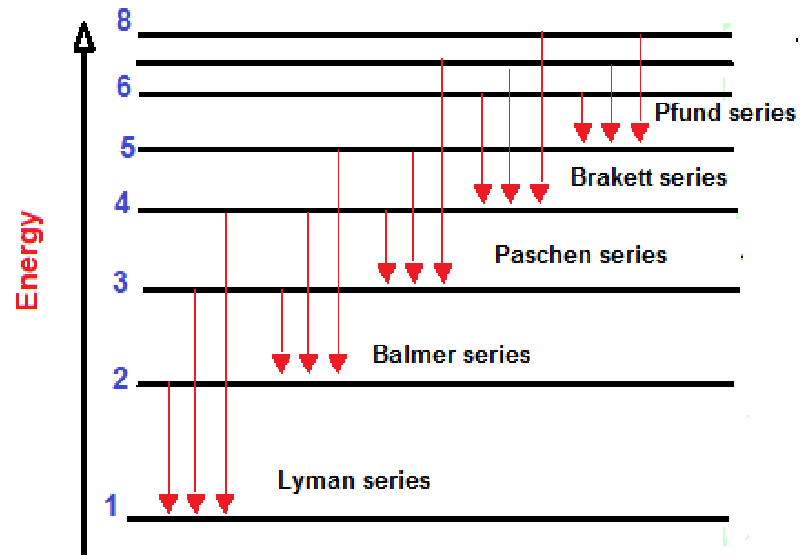
"STAR EATING BLACK HOLE", "Scientists watch a black hole shredding a star" (NASA, OSU 2019)

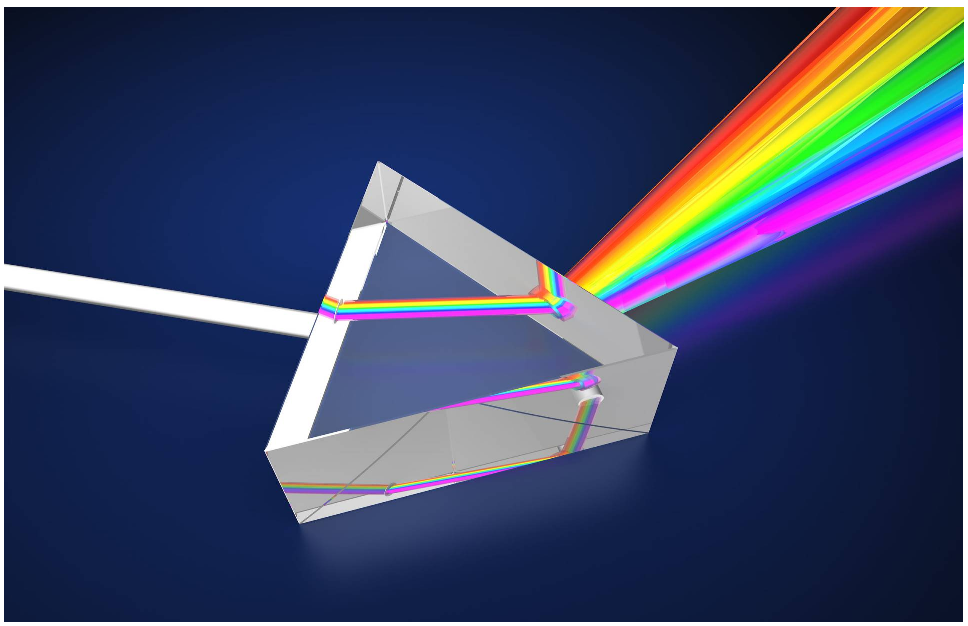


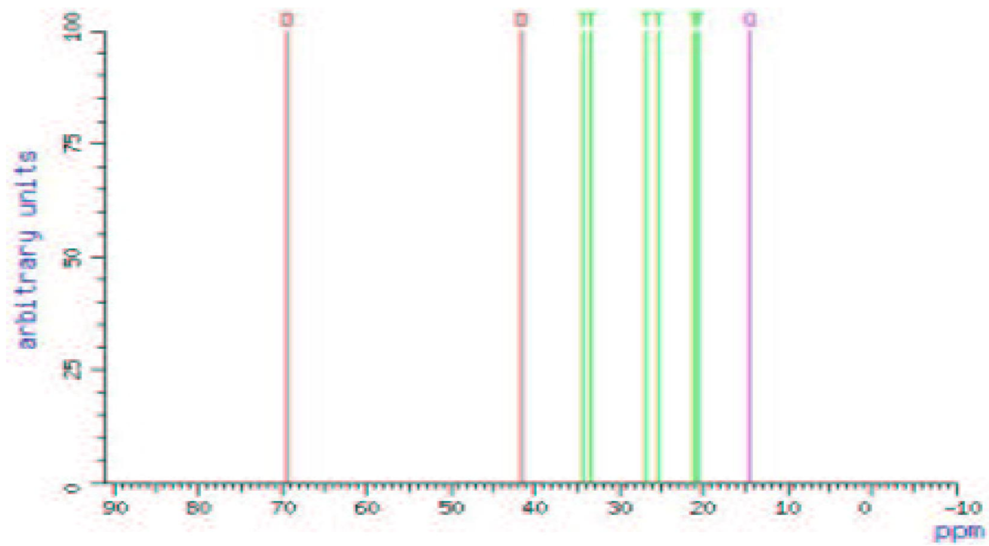
- Detected by TESS of NASA, AASA-GN led by OSU
- Tidal disruption event (TDE) - when a star gets too close to a black hole
- Depending on a number of factors, the black hole can either absorb the star or tear it apart into a long, spaghetti-like strand

RADIATION FROM ATOMS & SPECTRUM



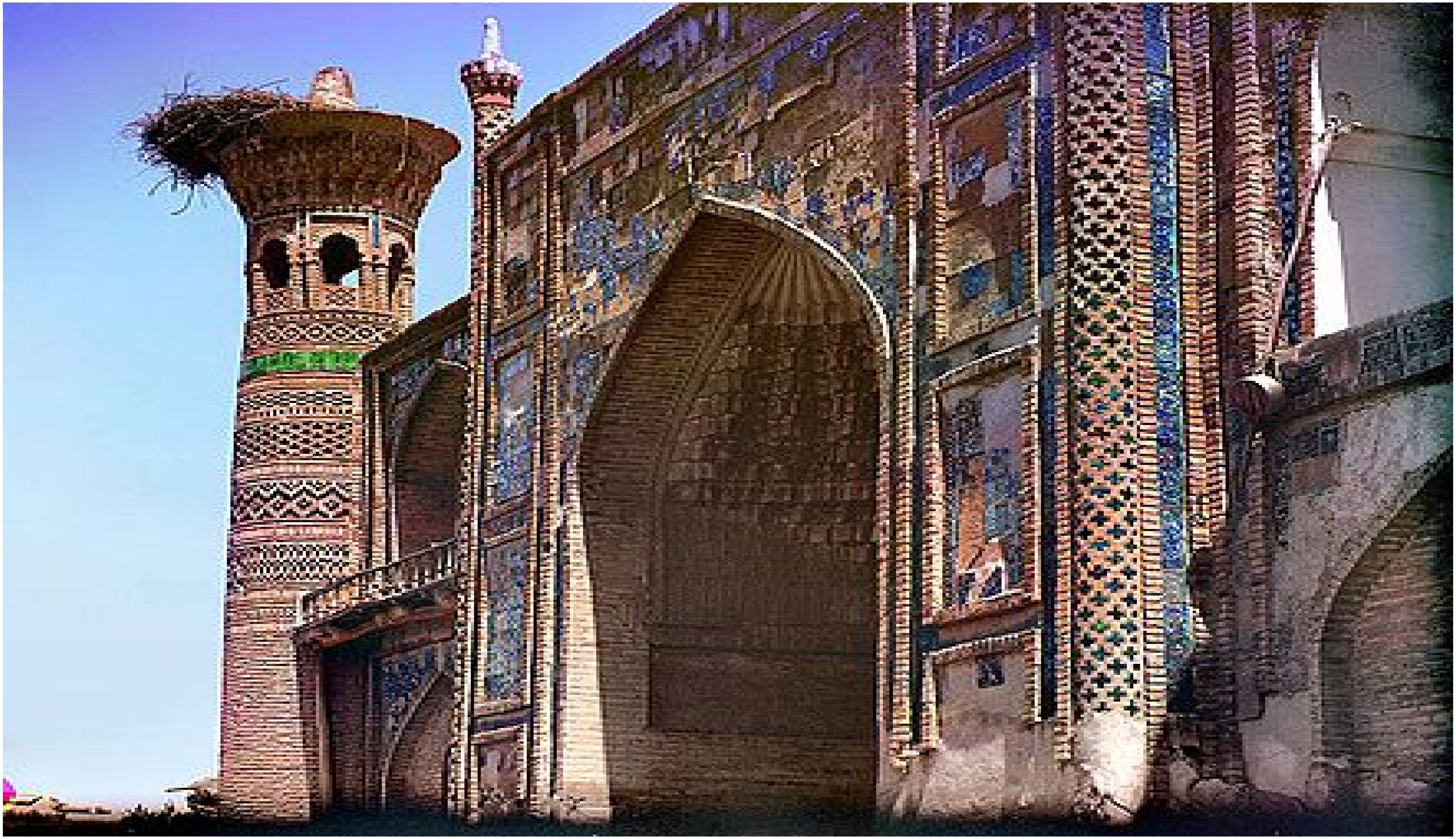






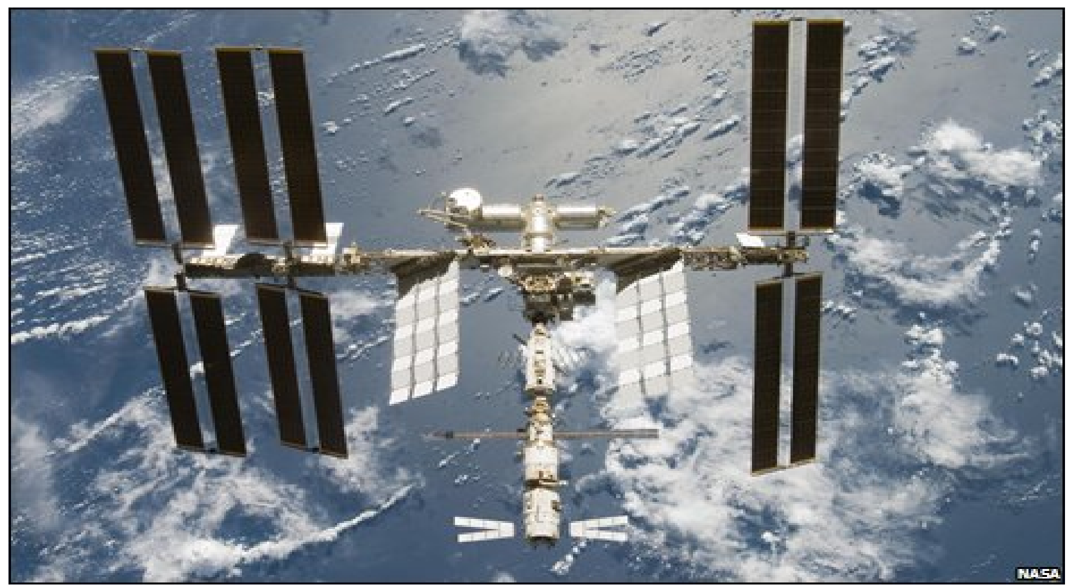
- Energy levels are quantized
- An electron can be excited to higher levels. While dropping down, it gives out a photon. Radiation contains photons of many energies
- SPECTURM: Splitting the radiation in to its colors: Rainbow, C

THE 1ST OBSERVATORY, SAMARKAND, 1420, BY MUSLIM RULER ULUGH BEG (Iran has an older model)



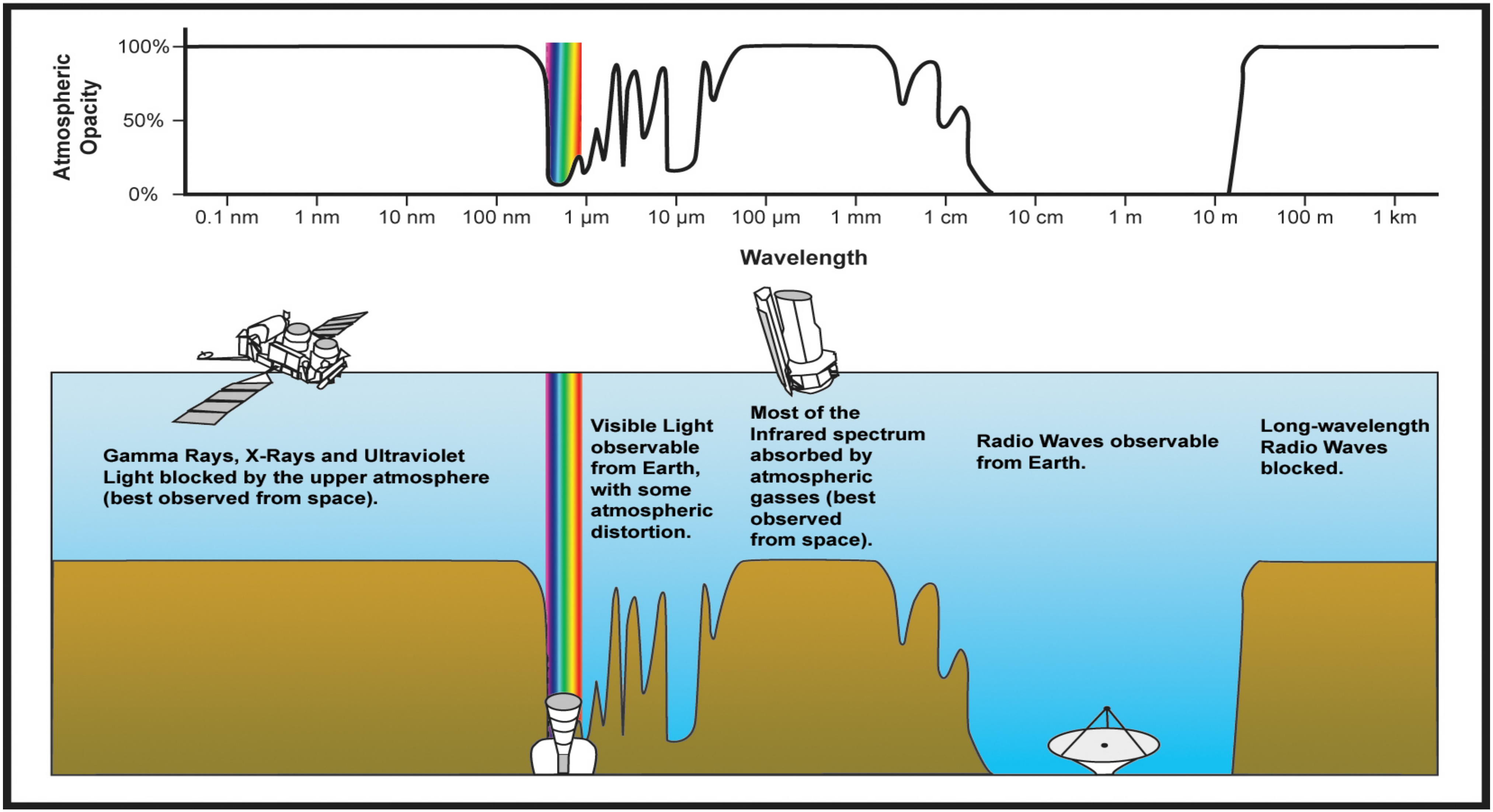
- **Ulugh Beg built the madrasa in 1420 in Samarkand and extended it to an observatory**
  - **Beg himself recorded many astronomical objects.**

Large Binocular Telescope in Arizona (8.4m Mirrors, NIR-optical)



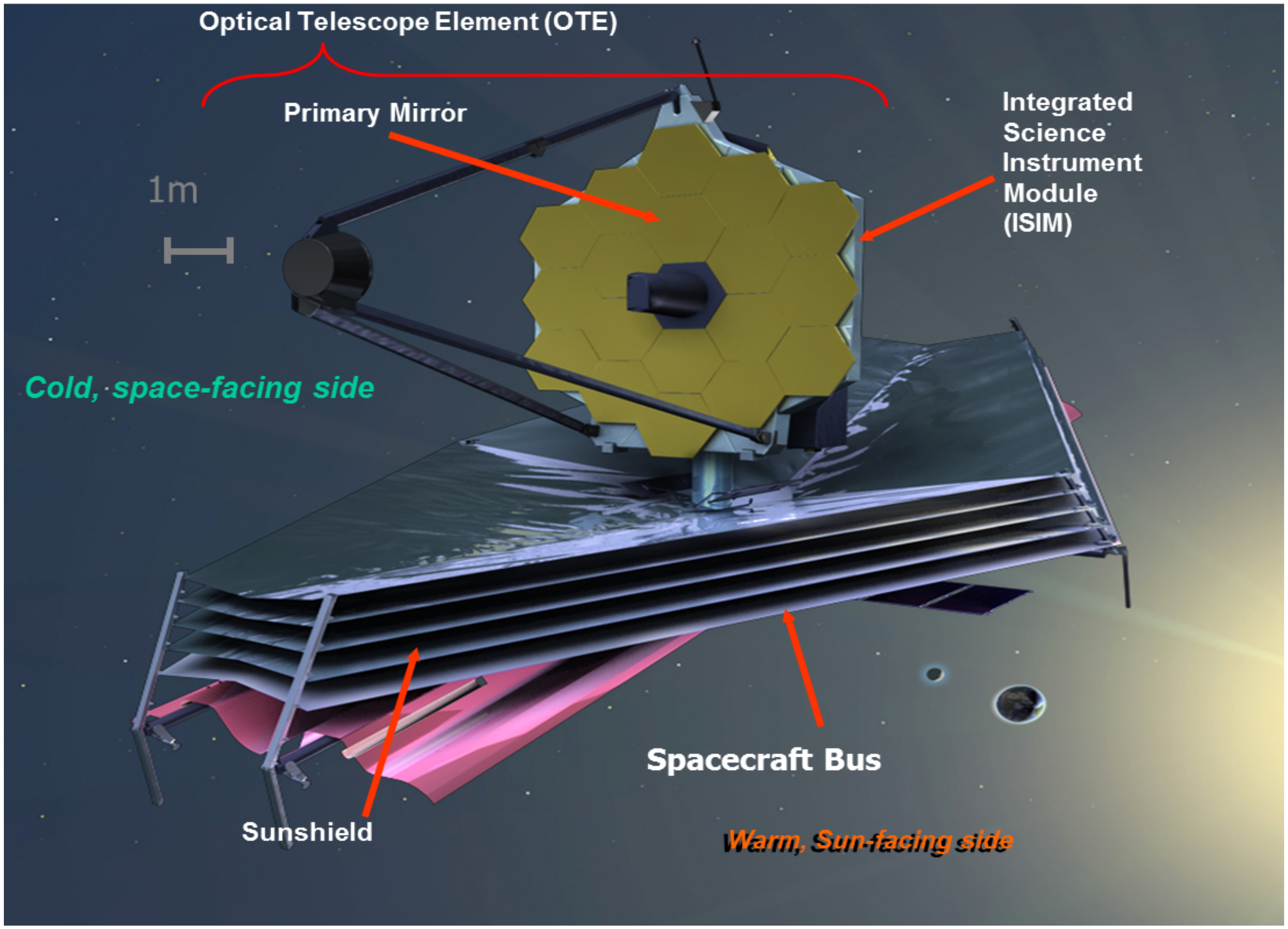
L: Hubble space telescope, R: International Space station of NASA

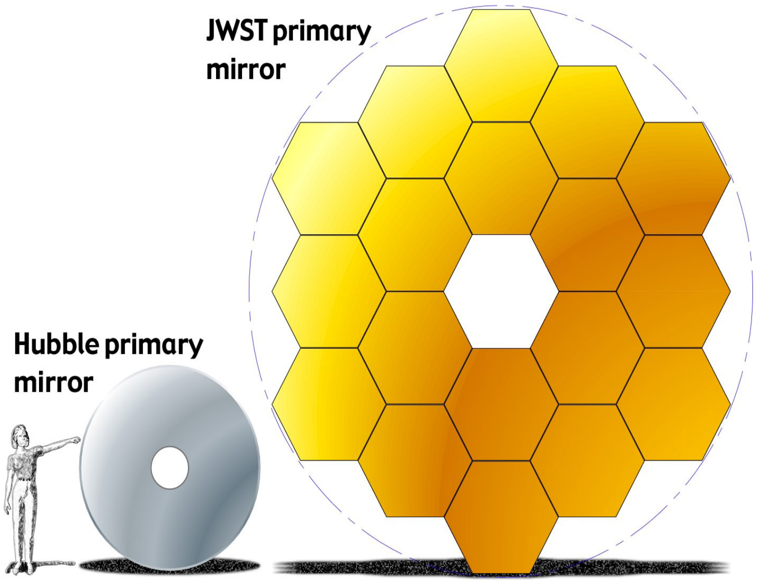
ATMOSPHERIC OPACITY - ABSORPTION OF RADIATION



- Higher opacity -less radiation reaching earths surface
- Opacity determines types of telescopes - earth based or space based
- Gamma, X-ray, UV are blocked while visible light passes through
- CO_2, H_2O vapor, other gases absorb most of the infrared frequencies
- Part of radio frequencies is absorbed by H_2O and O_2, and part passes through

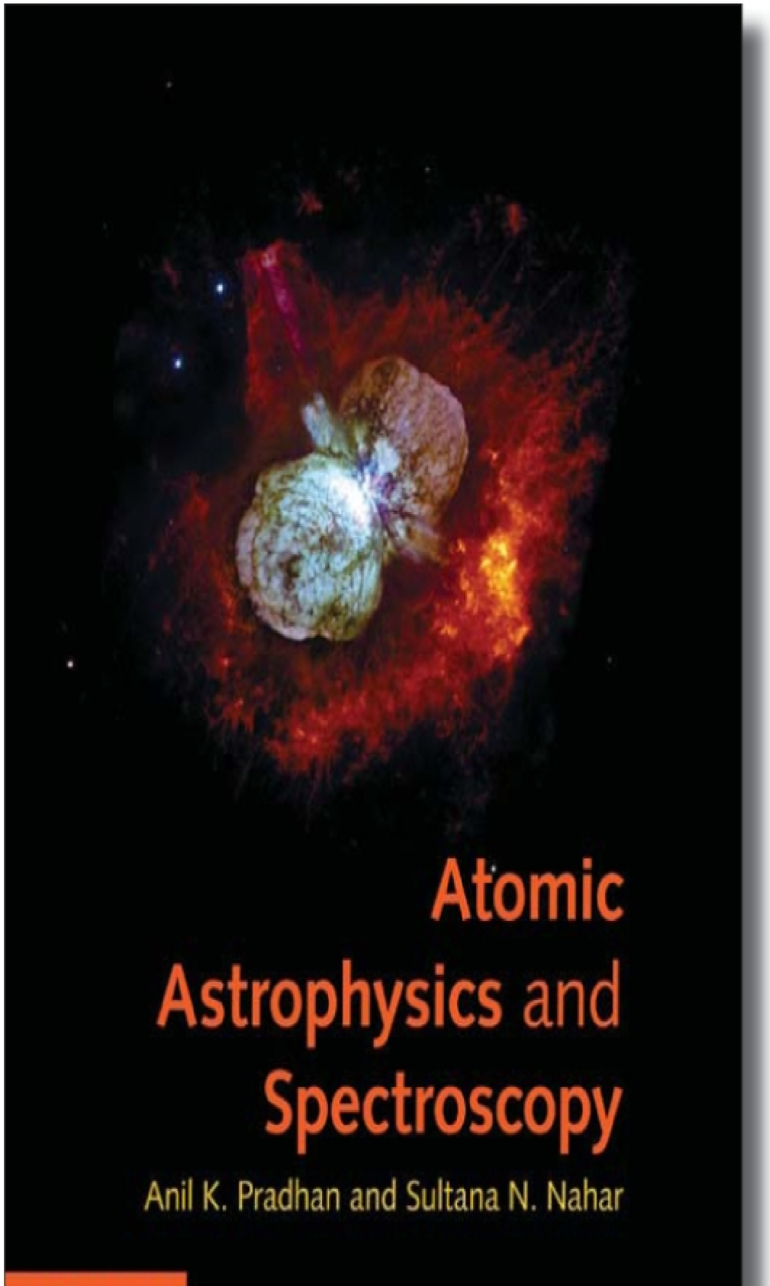
James Webb Space Telescope (JWST): Infrared 0.6 - 28.5 μm





- 18 mirrors combine to create 6.5m - Hubble: 2.4m diameter lens
- Mass: 6500 kg - Launch: March 2021
- Expected to detect lines of kilonova events

Determination of OPACITY: RADIATIVE ATOMIC PROCESSES



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and Arizona, Germany, Italy

Large Binocular Telescope (LBT)

Largest Telescope: 8.4m Mirrors (11.8m), NIR-Optical