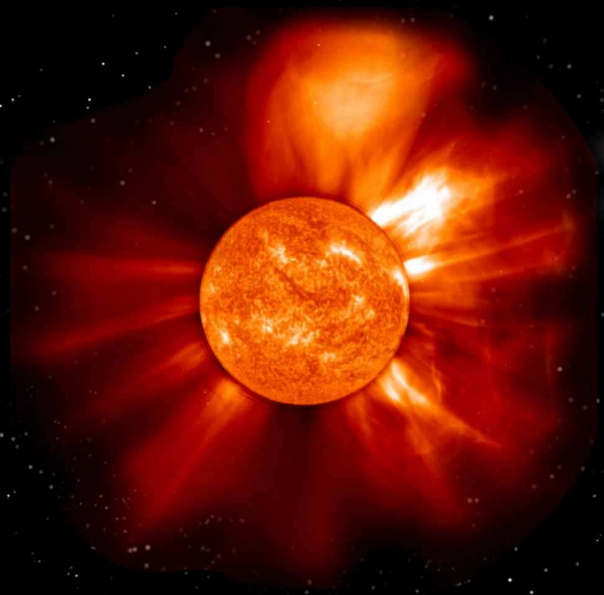
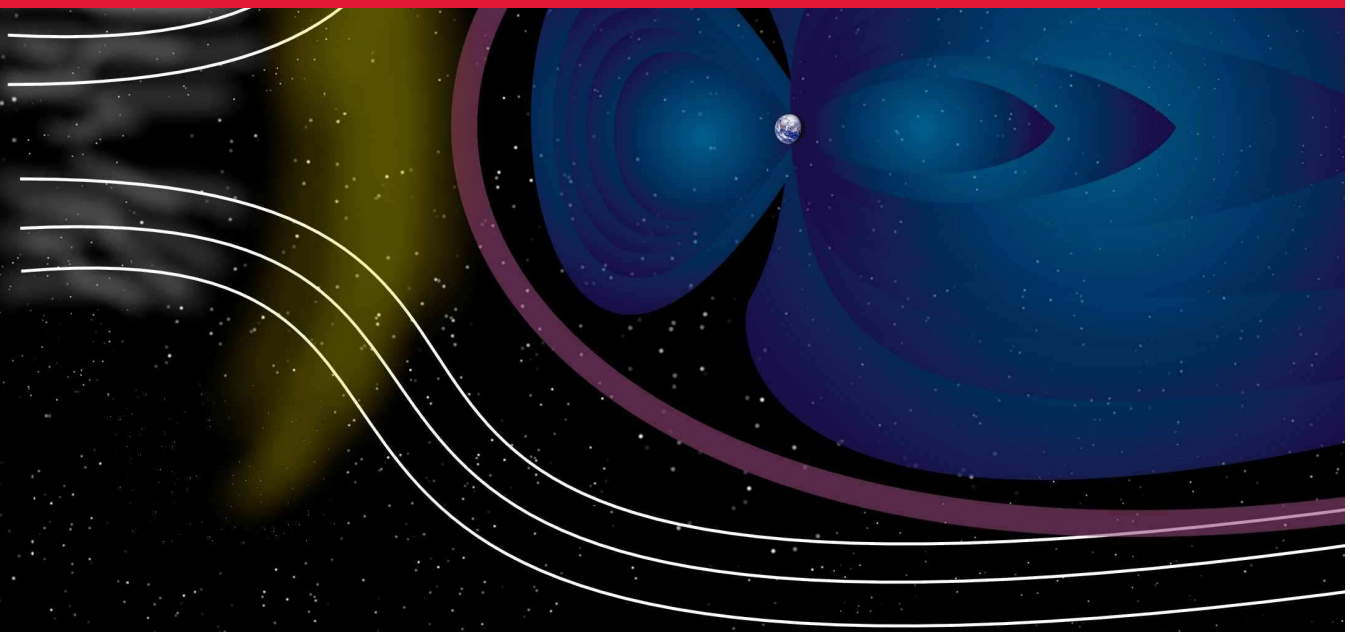
PHYS 3280

Physics of the space environment

W 2020/2021





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Professor Norbert Bartel

Course outline

PHYS 3280	MWF 13:30 - 14:30	ZOOM					
JANUARY		**FEBRUARY**		**MARCH**		**APRIL**	
Mon. 11	**1. Introduction**	Mon. 1	Atmosphere, cont.	Mon. 1	**Midterm exam**	Fri. 2	Interplanetary Medium, cont.
		Wed. 3		Wed. 3	Sun and A., cont.	Mon. 5	
Wed. 13	**2. Neutral Upper Atmosphere**	Fri. 5	**3. Sun and Absorption**	Fri. 5	**4. Ionosphere**	Wed. 7	**7. Orbital Debris and Micro-meteorites**
Fri. 15		Mon. 8		Mon. 8		Fri. 9	
Mon. 18		Wed. 10		Wed. 10		Mon. 12	
Wed. 20		Fri. 12		Fri. 12			
Fri. 22		Mon. 15	**Reading Week**	Mon. 15			
Mon. 25		Wed. 17		Wed. 17	**5. Magneto-sphere**		
Wed. 27		Fri. 19		Fri. 19			
Fri. 29		Mon. 22	Sun and Absorption, cont.	Mon. 22			
		Wed. 24		Wed. 24			
		Fri. 26		Fri. 26			
				Mon. 29	**6. Inter-planetary Medium**		
				Wed. 31			

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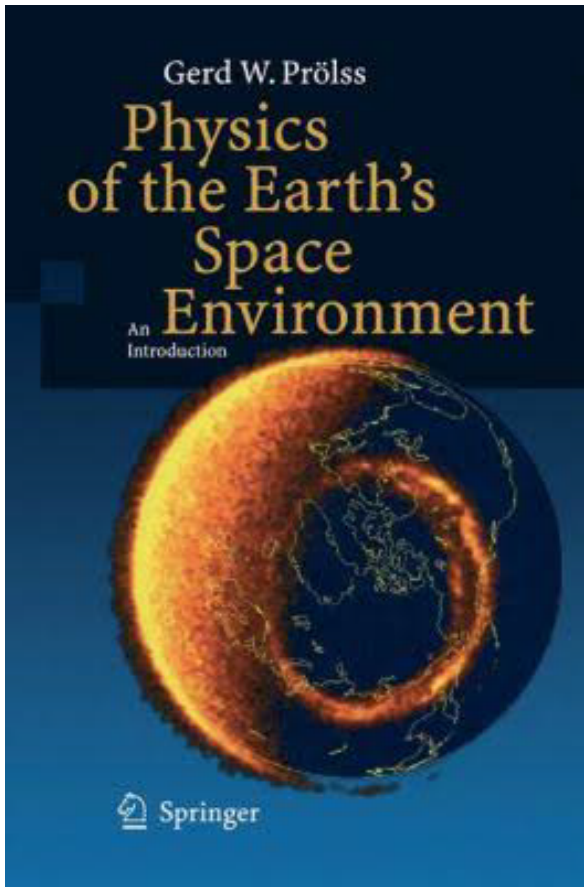
Course textbook

Gerd Prölss, “Physics of the Earth’s Space Environment: An Introduction”, translated by Michael Keith Bird, Springer-Verlag, Berlin 2010 ISBN 978-3-642-05979-7



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Introduction

Space physics: Physics of particles and fields within the space regions of the solar system and its immediate vicinity.

Particles: atoms, molecules, ions and electrons

Fields: electric, magnetic, gravitational…

Space regions: Neutral atmosphere

Ionosphere

Magnetosphere

Solar atmosphere

Interplanetary space

Heliosphere

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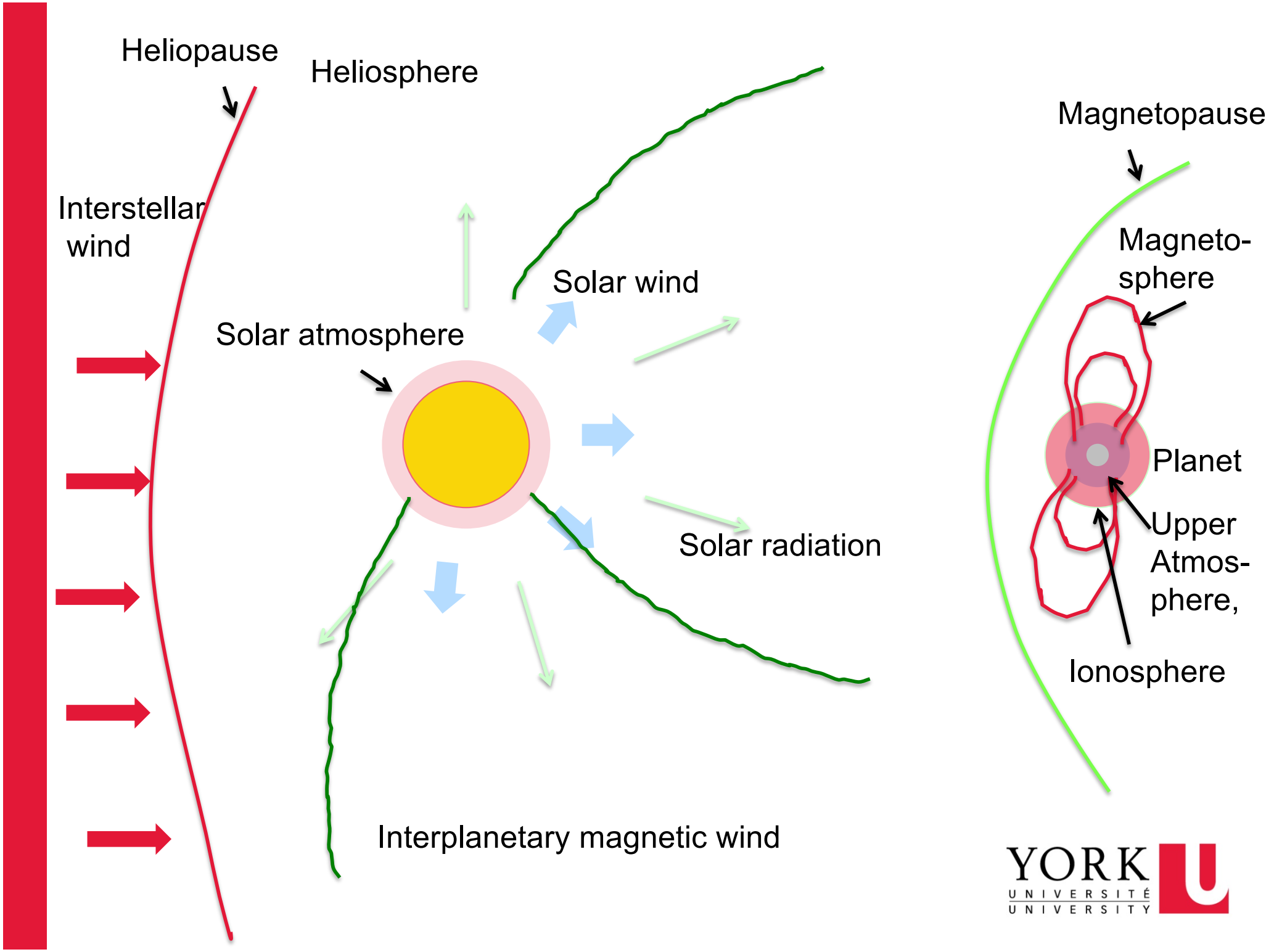

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Demarcation of scientific disciplines

Solar physics
Planetology < Space physics < Astronomy
Meteorology

100 km < Space physics < 1000 AU

Earth radius < Heliopause < Nearest star
6371 km 100 AU 270,000 AU

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Did you know?

- The first animal in space was a Russian dog named Laika, aboard Sputnik in 1957.

- In 2012, Austrian sky diver Felix Baumgartner ascended to a height of 39 km aboard a capsule attached to a 55-story-tall helium balloon. He was less than half way up to what we consider space. Baumgartner jumped and shot to earth at a speed of 1,343 km/h, reaching Mach 1.24, and became the first person to break the sound barrier without vehicular power on his descent. It took 9 minutes for Baumgartner to reach the ground.

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Scope and organization of the course

- The course is biased toward the space environment of the Earth and touches only sporadically on the space environment of the other planets of the solar system.
- Essentials of the Earth's immediate space environment can be relatively easily transferred to the immediate space environment of the other planets. For instance, the underlying physics for Earth's aurora are similar to the underlying physics for the aurora phenomena of Jupiter and Saturn.
- The order of the chapters follows the order of increasing distance of the regions that are covered in the chapters, and the regions' impact on spacecraft is discussed.

Main chapters

① Introduction
② Neutral upper atmosphere
③ Sun and absorption
④ Ionosphere
⑤ Magnetosphere
⑥ Interplanetary medium
⑦ Orbital debris and micrometeorites

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History

Groundbased observations related to Earth's magnetic field

~1000 -------- magnetic compass discovered in China

1600 Gilbert - Earth magnetic field investigated with compass needle

1722 Graham – Short period magnetic field fluctuations

1808 Humboldt – Irregular magnetic field disturbances ➔ magnetic storms

1839 Gauss – small part of magnetic field is extraterrestrial

1842 Schwabe – Solar sunspot cycle

1849 Barlow – First space weather effect: disturbance of telegraphic communications during geomagnetic storms

1852 Sabine – Intensity of magnetic disturbances correlated with sunspot cycle

1859 Carington – Solar flares can be followed by magnetic storms

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Groundbased observations related to the aurora

1733 de Mairan –description of auroras and speculation about the cause: solar particles penetrate Earth's atmosphere and generate polar lights.

1741 Hjorter & Celsius – Intense magnetic field perturbations occurred during enhanced auroral activity

1866 Ångström– Recording of prominent greenish yellow auroral line at 557.7 nm

~1895 Birkeland – First experimental simulation of an aurora

~1895 Størmer – Calculation of trajectories of electrical particles in Earth magnetic field

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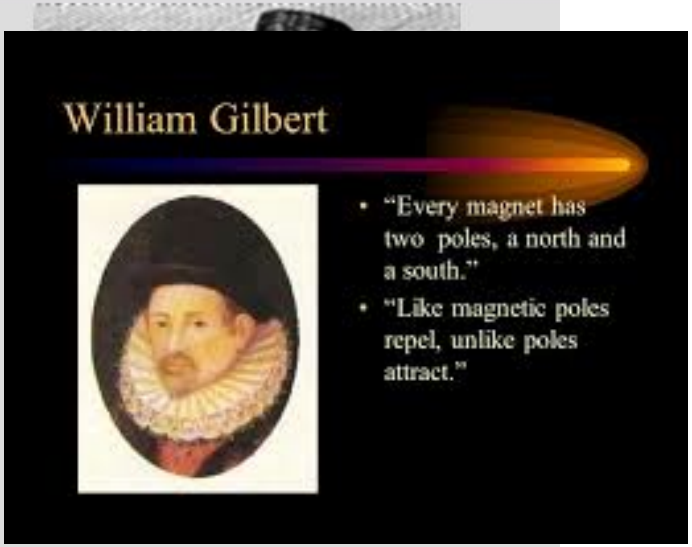
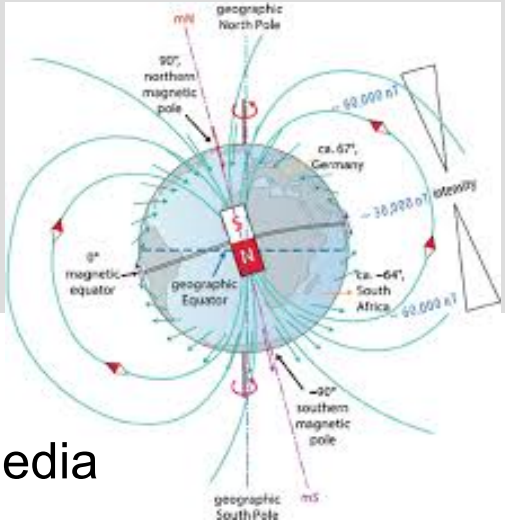
William Gilbert and the Birth of Magnetism

- Personal Physician to Elizabeth I
- Published De Magnete in 1600, a 6-volume treatise documenting his experiments with magnetism
- Proposed that Earth behaves like a giant bar magnet
- Died in 1603 of bubonic plague



William Gilbert,
1544-1603

http://www.phy6.org/earthmag/demagint.htm



Note: all of the portraits are from wikipedia

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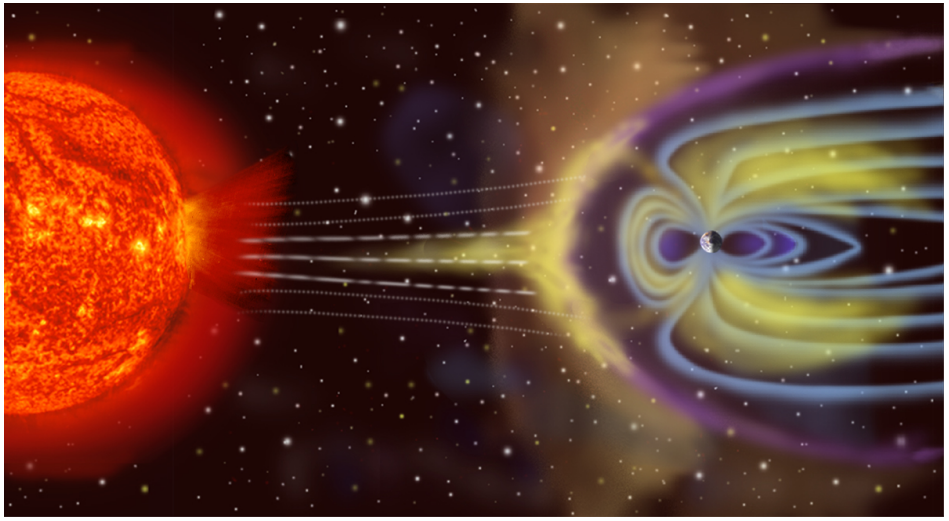
Erratic behavior of compass needle during bright auroral event- magnetic storm



Wikipedia

Von Homboldt urges Gausss to study magnetism

Alexander von Humboldt
Naturalist, 1769-1859

Painting by Joseph Stieler 1843

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- Gauss invents a device to measure the strength of a magnetic field.
- Suggests to build magnetic observatories.
- 1834 Gauss founds "Göttingen Magnetic Union," later (1836-9) develops spherical harmonic analysis of the scalar magnetic potential.

Carl Friedrich Gauss 1777-1855
painted by Christian Albrecht Jensen

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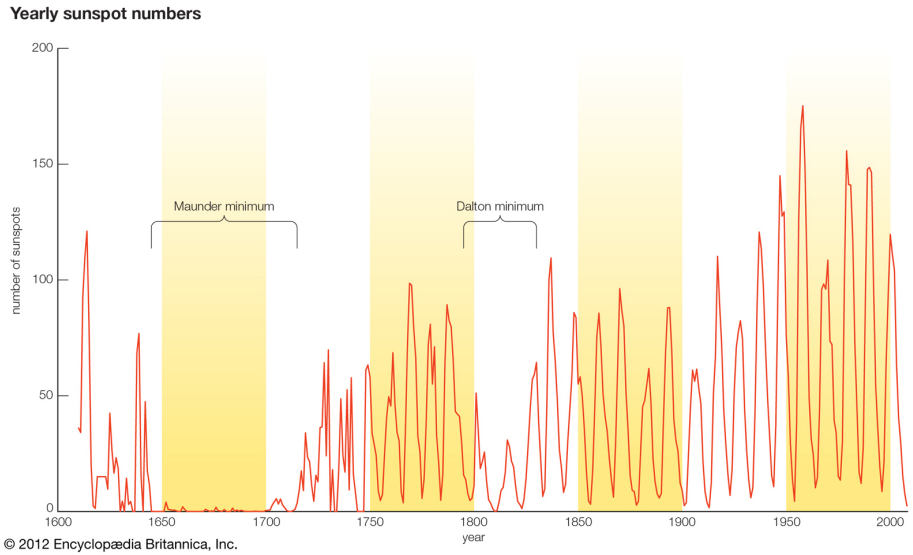
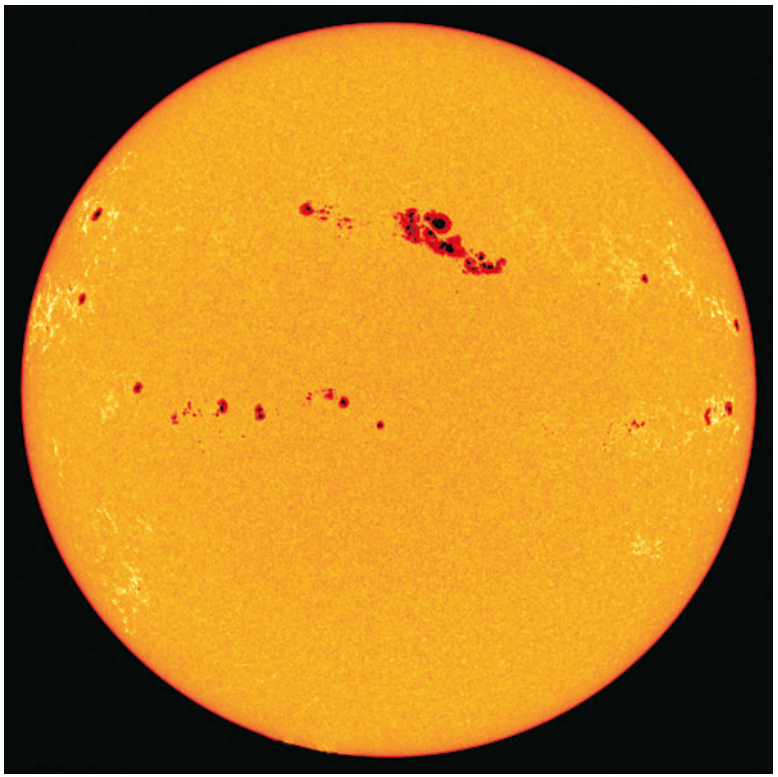


Schwabe discovered sunspot periodicity



https://hurricanemanagementgroup.com/sunspot-activity-sunspots-cycle-definition/

Heinrich Schwabe
1789-1875

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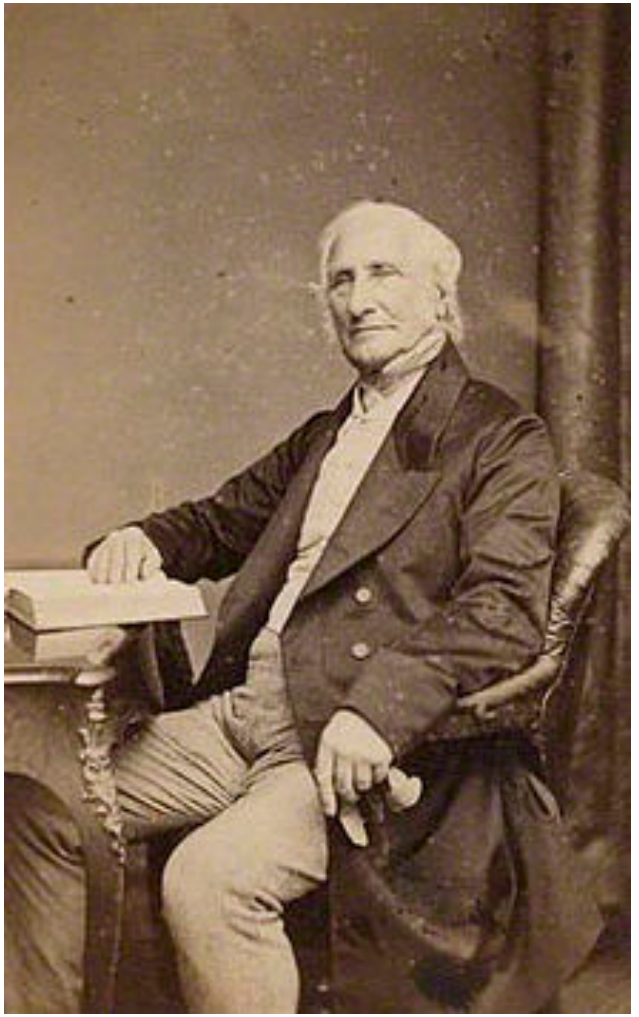
- Sabine led effort to build magnetic observatories all over the globe
- From Toronto recordings è magnetic variations closely correlate with variations in the number of sunspots.
- 11 year sunspot cycle identical to 11 year geomagnetic cycle



Joseph Sabine
1788 - 1883

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Aurora description and speculation about cause

Jean-Jacques Dortous
De Mairan
1678-1771

en.wikipedia.org

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Kristian Birkeland experiments with a magnetized sphere ("terrella") in a vacuum chamber and electrons shot at it. The electrons found their way to the magnetic poles è polar aurora is probably created by electron beams from the Sun.

Kristian Birkeland
1867-1917

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Groundbased observations of the ionosphere

1901 Marconi – Transatlantic radio communication ➔ speculation about conducting layer

1924 Breit, Tuve, Appleton (Nobel Prize), Barnett – Prove of existence of ionosphere

>1924 Chapman – Theory of ionosphere

1925 Espenschied – Ionospheric disturbance ➔➔ geomagnetic activity

1953 Storey – whistlers: low-frequency radio waves propagating in magnetized ionized gases, extension of ionosphere into magnetosphere

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Marconi sends radio signals across the Atlantic ocean, made possible by the reflecting nature of the Ionosphere

1909 Nobel Prize

Guglielmo Marconi
1874-1937

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Groundbased observations of the interplanetary medium

1942 Alfvén – extremely hot, ionized outer atmosphere

1951 Biermann – plasma flow from Sun on basis of comet tail observations

1958 Parker – Model of solar wind and interplanetary magnetic field

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1970 Nobel Prize for work on magnetohydrodynamics

Hannes Alfven
1908-1995

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Showed that the tail of ions of a comet flows away from the Sun with a speed of > 400 km/s.

Ludwig Biermann
1907-1986

britannica.com

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Developed the theory of supersonic wind in the interplanetary space

Developed the model of the "Parker Spiral of the magnetic field in the outer regions of the interplanetry space Eugene Parker
1927 -

Eugene Parker
1927 -

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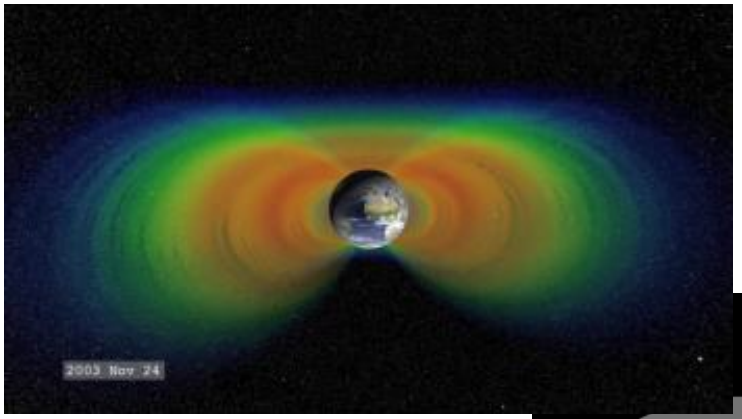
Spacebased observations of the space environment

1949 USA -- refurbished German V2 rocket, launch into upper atmosphere, solar UV and X-ray observations

1957 Soviet Sputnik, first artificial satellite

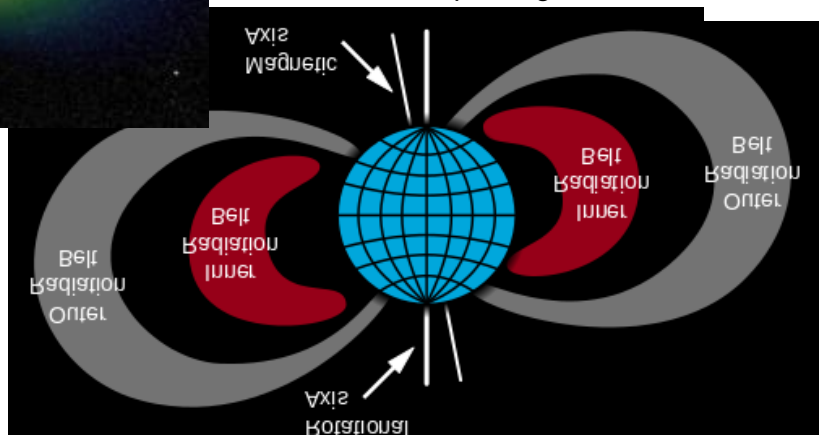
1958 USA, Explorer 1 Earth orbit

1958 USA, detection of Van Allen radiation belt



spaceflightinsider

German V-2 rocket. 1942 WWII



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