

Some Dates in the Exploration of the Magnetosphere

Dates in red are from the basic timeline of events related to "Exploration of the Earth's Magnetosphere".

Dates in black are from the history of society and technology, and are meant to provide a broader context for the dates in the basic list.

If connected to the internet, [click here](#) for a similar but broader chronology on astronomy and space, extending from antiquity to 2004. If using a CD, go to folder "stargaze" and open there "Stimelin.htm" .

- **~1000--Magnetic compass discovered in China**
 - **1000-1400** Age of **feudal lords** in Europe: castles, knights, religious fervor, only very rudimentary science and technology. Also the age of the **Vikings**, some of whom sailed as far as Greenland and America. **Mongols** overrun and subjugate southern **Russia**.
 - **1095-1291 Crusades**
 - **1460** Johann Gutenberg invents the **printing press** with movable type. Combined with **paper** (another Chinese invention which gradually reached Europe and displaced parchment), the printed book is a major force in a cultural and technical growth spurt, the **Renaissance** (French for "rebirth").
 - **1492** Columbus discovers **America**, followed by Spanish (and some Portugese) explorers. The main powers in Europe are **Spain, France, England, Turkey** and a confederation of **German** princes ("Holy Roman Empire").
 - **1543 Copernicus**, a Polish cleric, publishes his theory that the Earth is a planet revolving around the Sun.
 - **1588** The "**Spanish Armada**," a fleet attacking Britain, is destroyed by the British navy and by storms. For the first time Britain is able to claim part of the American continent.
 - Europe and Asia are introduced to American crops--potatoes, tomatoes, corn. Europe's diet is also gradually enriched by sugar, oranges and pepper, originating in India.
- **1600 William Gilbert** publishes in London "De Magnete" ("on the magnet"). His explanation of the compass: the Earth is a giant magnet.
- **1609--Galileo Galilei** builds in Italy the **first astronomical telescope** and observes mountains on the Moon, **sunspots** (also discovered independently by **Christopher Scheiner and Johann Fabricius**), 4 moons around Jupiter and a crescent-like Venus, changing its shape the way the Moon does. His observations convince him that Copernicus was right.

That same year **Johann Kepler** in Prague formulates his first two laws--that planets move in ellipses, and that they speed up as they approach the Sun according to a certain formula; these are shown by **Isaac Newton** in 1684 to be a direct result of Newton's law of gravitation.

- After a failed attempt (1586) to establish a colony on Roanoke Island, Virginia (now part of N. Carolina), Jamestown is founded in Virginia in 1607, and the first English settlers land in Massachusetts Bay in 1620 (the "**Pilgrims**").
- A century after Martin Luther broke away from the Roman church, religious wars sweep Europe. The **30 years' war (1618-1648)** devastates Germany and establishes Sweden as a major military power. In the civil war in England, parliament suspends monarchy 1645-1660, king beheaded 1649.
- The **Turkish** army reaches Vienna (**1683**) but is repelled; among the booty the victors discover **coffee**, develop a taste for it. Englishmen begin smoking tobacco, an American plant.
- **1708**---Abraham Darby begins extensive iron production in England, based on roasted coal (coke). As firewood gets scarce, **coal** becomes England's choice fuel and coke replaces charcoal in iron production. To run the pumps that keep coal mines dry, Newcomen in 1712 invents a crude steam engine.
- **1712**---Russia's king (czar) Peter the Great "opens a window to the West" by founding a new capital, which he names **St. Petersburg** and which becomes Russia's main port on the Baltic sea.
- **1741**--Hiorter and Celsius note that the polar aurora is accompanied by a disturbance of the magnetic needle.
- **Britain's colonies in America** achieve a growing degree of self-sufficiency. Benjamin Franklin prints books in Philadelphia, also demonstrates (1749) that lightning is an electrical phenomenon. Later (**1775-1783**) the colonies rebel against Britain, win their independence and form a confederation. In 1787 they write a constitution and form a federal republic.
- **1769**---James Watt in Britain invents a greatly improved **steam engine**; In 1807 Robert Fulton uses steam to run the first commercial paddlewheeler on the Hudson river;
- **1777 Charles Augustin de Coulomb** in Paris builds a sensitive magnetometer, using a magnet suspended by a long flexible string. Using this, he proves that the magnetic attraction (and also the electric one) decrease like the inverse square of the distance.
- **1781**---William Herschel, a German musician settled in Britain, discovers the **planet Uranus** with a mirror telescope he had constructed.
- **1783**---The Montgolfière brothers in France, owners of a paper factory, build the first **hot air balloons**; balloons lifted by hydrogen follow.
- **1789**---The **French Revolution**: France rebels against its king, who is later deposed and executed. The French follow the US example and set up a republic, but a military officer, Napoleon Bonaparte, gradually gains power. From **1798 to 1815** France under Napoleon fights a series of wars and for a while rules or controls most of the European continent.
- **1793**---Alexander Mackenzie **crosses Canada** from coast to coast. After the **1803** US purchase of **Louisiana** from Napoleon, **Meriwether Lewis** and **William Clark** cross the continent with their exploration party, from St. Louis to the mouth of the Columbia River.

- **1796**---Edward Jenner in Britain introduces **vaccination** against smallpox.
- **1803**---John Dalton, a chemist, argues that observations in chemistry require matter to be composed of **atoms**.
- **1820**--Hans Christian Oersted discovers electromagnetism. André-Marie Ampère deduces that magnetism is basically the force between electric currents.
- The Industrial revolution: George Stephenson in Britain (**1825**) and Peter Cooper in the US (**1830**) found successful **railroads**, run by steam. Mass production of fabric and paper. **Henry Bessemer** in 1856 finds way to mass-produce steel.
- **1826**---crude **photography** by L.J.M. Daguerre, greatly improved in decades that follow.
- 1829--Joseph Ressel (a Czech forester employed by the Austrian Navy in Trieste) builds and tries out a simple **ship's propeller**. Later in 1836 John Ericsson patents the propeller and develops it further.
- **1837**--Samuel Morse invents his **telegraph**; 1844 first commercial telegraph line opens, by 1866 undersea telegraph cables link Europe and America.
- **1846**---**Anesthesia** by ether is introduced by William T. Morton in Boston.
- **1849**---California **gold rush**.
- **1851**--Samuel Schwabe, a German amateur astronomer, announces the discovery of the 11-year sunspot cycle.
- **1856**---Commodore Perry and a US fleet open up **Japan** to western culture and technology; rapid modernization follows, enabling Japan to defeat Russia in war less than 50 years later.
- **1859**--Richard Carrington in England observes a violent and rapid eruption near a sunspot; 17 hours later a large magnetic storm begins.
- **1859**---Charles **Darwin** publishes "Origin of the Species"
- **1859**---Edwin Drake extracts **petroleum** from an oil well in Titusville, Pennsylvania. Beginning of a world-wide effort to find and extract oil, refine it and use its constituents for light, heat and later to run gasoline and diesel engines.
- **1861**---**Italy** unified under the king of Piedmont; 1850-70, **Germany** unified under Prussian leadership..
- **1860-65**--US Civil War
- **1865**---Joseph Lister introduces antiseptics to surgery, cutting its risks.
- The **Industrial revolution** continues: bicycles are introduced (high-wheelers, then "safety models"), mass production of fabrics, also Brooklyn Bridge (**1883**), Statue of Liberty (**1886**), Eiffel Tower (**1889**)
- **1885-1900**---After the introduction of electric train engines, the construction of **subways** begins in the major cities of Europe (starting with London, then Budapest) and the US (starting with Boston, then New York).

- **1870**---**Suez Canal** opens, a shortcut between Europe and Asia.
- **1870**---**Railroad across the US**. In **1891-1905**, the trans-Siberian railroad is built.
- **1876**---**Telephone** invented
- **1879**---Edison invents the electric **lightbulb**, initially using a fragile carbon filament.
- **1882**---**Electric power stations** in London and New York. Large scale refrigeration.
- **1884**---Charles Parsons invents his **steam turbine**, which ultimately becomes the preferred power plant of electric power stations and ships. Diesel engine introduced by Rudolf Diesel in 1897.
- The beginning of **automobiles** (Marcus 1864 in Austria; Benz, 1887 in Germany; Duryea, 1893 in the US).
- **1890**---Nitrocellulose photographic **film** introduced (George Eastman of Kodak, Rochester NY), making possible the first "movies."
- **1892**--George Elery Hale introduces the spectroheliograph, observing the Sun in the light of a single spectral line such as H- α . Using it he observes a solar flare and confirms the connection between flares and magnetic storms.
 - Age of exploration and colonization in Africa.
- **1900-3**--Kristian Birkeland experiments with beams of electrons aimed at a magnetized sphere ("terrella") in a vacuum chamber. The electrons hit near the magnetic poles, leading him to propose that the polar aurora is created by electron beams from the Sun.
- Birkeland also observes magnetic disturbances associated with the aurora, suggesting to him that localized "polar magnetic storms" exist in the auroral zone.
- **1902**--Marconi successfully sends radio signals across the Atlantic Ocean. Oliver Heaviside suggests that the radio waves found their way around the curving Earth because they were reflected from electrically conducting layer at the top of the atmosphere.
 - **1903**---**Wright brothers** fly at Kitty Hawk, North Carolina.
 - **1906**---Lee De Forest invents the **triode**--the vacuum-tube device (based on the Edison effect) by which weak electric signals can be greatly amplified . It makes possible radio, sound films, loudspeakers and later a whole generation of electronic devices.
 - **1909**---L.H.Baekeland introduces "bakelite", first mass-produced **plastic** material. It is widely used as electrical insulator.
 - **1904-1914**---**Panama canal** is built.
 - **1911**---Amundsen reaches **South Pole**.
 - **1912**---Emperor overthrown in **China**, republic proclaimed.

- **1914-1918--World War I.** The main opponents are Germany, Austria and Turkey, lined up against Russia, France, Britain, Italy. In 1917 Russia withdrew, defeated, and the Czar was overthrown by Communist workers (Russian Revolution) but the US entered to help Britain, whose side prevailed. A very large, destructive war, the first in which technology played a major role, including airplanes, tanks, machine guns, submarines and poison gas.
 - **1916**---Robert Goddard designs the first modern **rocket** motor; in 1926, launches first liquid-fuel rocket.
 - **1926**--Gregory Breit and Merle Tuve measure the distance to the conducting layer in the high atmosphere, the one from which radio waves are reflected, by measuring the time needed for a radio signal to bounce back from it.
 - R. Watson-Watt proposes naming the layer "ionosphere."
 - **1927**---**Charles Lindbergh** flies solo from the US to Paris.
 - **1929**---The New York stock market crashes, beginning a long economic **depression**, in the US and across the world.
 - **1922 to 1925**---**Fascism**, the creed of a strong, all-controlling government, gains power in Italy under Benito Mussolini. In Russia in 1924, Communist leader V.I. Lenin, dies; after that Joseph **Stalin** gradually gains power, kills or exiles all his rivals and institutes a reign of terror.
 - **1930**---In Germany, hard-hit by the economic hardships following WW-I and by the world-wide depression, the Fascist **Nazi party** under Adolph Hitler is 2nd in the polls in 1930, takes power 1933.
 - **1930-1931**--After Birkeland's "electron beam" theory is disproved, Sydney Chapman and Vincent Ferraro in England propose that magnetic storms are caused when plasma clouds ejected from the Sun envelop the Earth.
 - **1927-1930**---**Talking films** (black and white). "The Wizard of Oz" (1939) pioneers color movies, but more than 10 years pass before color films become prevalent.
 - **1932**---Sulfa drugs, first new anti-bacterial weapon. Penicillin follows during World War II, and other **antibiotics** are developed after the war.
 - **1936**---The **DC-3**, the first modern airliner, can reach 210 mph with 21 passengers.
 - **1939-1945 World War II.** A world-wide conflict is started by Hitler's Germany, whose army annexed Austria and Czechoslovakia, then attacked Poland. Germany was allied with Italy and after December 1941 with Japan, which launched its own war of expansion (it had invaded China years before that). A war with unsurpassed destruction and cruelty, including Hitler's attempt to exterminate the Jewish people, of whom about 6 million were killed in a deliberate plan. Technology played an even greater role than in World War I, including long-range bombing raids, improved submarines, jet engines, radar and towards the end, large military rockets and nuclear bombs. Opposing Hitler were France (which fell to the Germans), Britain, Russia and after 1941, the United States: 1941-3 the Germans became bogged down in brutal winter fighting in Russia, in 1943 the US and its allies invaded Italy and forced its surrender, then in 1944 they invaded France and in 1945 first Germany and then Japan surrendered. In 1945 in San Francisco, the victors formed the "**United Nations**", an international union whose major role was

to ensure peace and arbitrate conflicts.

- **1943**---Oswald Avery at the Rockefeller Institute in New York proves that **DNA**, a hitherto unexplained substance in all nuclei of living cells, carries the genetic information.
- **1947**---**India** becomes independent, along with a great number of colonies (especially in Africa), as Britain and France dismantle most of their empires. **Indonesia** is established in 1949.
- **1948-1949**---The "**cold war**" between the western allies (Britain, France and the US) and the Soviet Union begins with a blockade of Berlin by the Soviets, who try to force out the western allies. Contact is maintained for a year by a massive airlift.
- **1947**---**Transistor** invented, compact solid-state device that replaces the triode and is much more durable. In 1956 Bardeen, Brattain and Shockley are awarded the Nobel prize for this.
- **1949**--A sudden increase in cosmic rays is traced to an eruption on the Sun. A much larger event occurs in February 1956.
 - **1949**---The X-1 rocket airplane of the United States exceeds the **speed of sound**.
 - **1949**---A million **TV** receivers (black-and-white) in the US; two years later the number reaches 10 million.
 - **1949**--Britain puts the first **jet airliner** into service, the Comet. It is later withdrawn because of structural faults, but by 1958 the French Caravelle and the larger Boeing 707 jets enter service. Gradually jets begin dominating air transport, while travel by ocean liners declines sharply.
 - **1950**---The "**Marshall Plan**" of US general George C. Marshall revitalizes the European economy by providing extensive but judicious aid.
 - **1950**---**North Korea** invades South Korea. The US army stops the invasion and after a while enters North Korea, but a major intervention by China's army forces a stalemate.
 - **1951**--UNIVAC, first large electronic **computer**, built by Sperry-Rand.
- **1953**--Owen Storey proves that "whistler" radio waves are produced by lightning and are often guided through distant space along field lines of the Earth's magnetic field.
 - **1952**---United States explodes "Mike", the first **hydrogen** bomb, perhaps 500 times more powerful than the nuclear "atomic" bomb.
 - **1953**---Edmund Hillary and Tenzing reach the top of **Mt. Everest**.
- **1954**--Meredith, Gottlieb and Van Allen use a rocket in the auroral zone to detect radiation from the aurora.
 - **1954**---Following a supreme court ruling, the US government **outlaws Black/White segregation** in public schools.
- **1955**--Radio emissions from Jupiter are detected, mystify observers.

1955---Jonas **Salk** develops vaccine against polio, followed (1960) by the Salk oral vaccine; disease is effectively eradicated.

- **1953-1958**---Watson and Crick show that DNA is a **double helix** and its mode of replication is established. By 1966 the "genetic code" is revealed, by which specific proteins are created. The beginning of modern molecular biology.
- **1956**--Soviet army crushes attempt of **Hungary** to break away from Communist block.
- **1956**---First large commercial **nuclear power** station, at Calder Hall, opens in Britain.
- **1957**-- -Sputnik 1 launched by the Soviet Union, the first artificial satellite.
- **1958**--Explorer 1, launched by the US January 31, observes the radiation belt; Explorer 3, launched in March, comes up with the first clear evidence for its existence. Sputnik 3, in May, also observes the radiation.
- Eugene Parker (Chicago) proposes the theory of the solar wind.
- Pioneer 3 observes the outer radiation belt.
- "Project Argus", 3 small nuclear bombs above the south Atlantic Ocean, creates (3 times) artificial radiation belts, lasting about 2 weeks. The project also creates artificial aurora.
 - **1958**---**Interstate highway** network in the US started.
 - **1958**---**NASA** established by President Eisenhower.
- **1959**--Thomas Gold proposes the name "Magnetosphere".
- **1961**--James Dungey in Britain proposes a mechanism for transmitting solar wind energy to the magnetosphere by direct magnetic linkage between the two.
- Ian Axford and Colin Hines (Canada) raise an alternative possibility, of energization by fluid friction at the boundary between the two.
- **1962**--The magnetopause, boundary between magnetosphere and the solar wind, is observed by Explorer 12.
 - **1962, 20 February**---John Glenn becomes first American in orbit.
- **1962**--In July, an H-bomb test ("Project Starfish") by the US above the central Pacific Ocean creates a radiation belt of high-energy electrons, parts of which remain until 1967. The new belt creates aurora at Samoa and unexpectedly knocks out 3 artificial satellites.
 - **1962**---The placing of Soviet Missiles on **Cuba** produces international crisis, which ends when the missiles are withdrawn.
 - **1963**---President J.F. **Kennedy** assassinated in Dallas, Texas.
 - **1963**---Nuclear **test ban** treaty
- **1964**--IMP-1 (Interplanetary Monitoring Platform 1) reports a large bow shock

formed in the solar wind ahead of the magnetosphere, and a long magnetic tail on the night side of the Earth.

- Syun-Ichi Akasofu (Japan-US) and Sydney Chapman revive and expand Birkeland's notion of a "polar magnetic storm", now named "magnetospheric substorm."
 - **1969, 20 July**---Apollo 11 astronauts **land on the Moon**.
- **1971**--Ionospheric oxygen ions found among energetic particles trapped in the Earth's magnetic field, evidence that O⁺ ions are pulled out of the ionosphere and accelerated (Ed Shelley et al., Lockheed).
- **1973**--Observations of the diffuse aurora are reported, made by the Canadian Isis-2 spacecraft.
- **1974**--A large-scale pattern of extensive electric currents flowing from space into the polar cap and out again is traced by Alfred Zmuda and Jim Armstrong of the Johns Hopkins U. Applied Physics Lab, using the Navy's "Triad" satellite.
 - **1975**---Viet Nam war ends.
 - **1975**---Steve Jobs and Stephen Wozniak create the first **personal computer**, the "Apple"
 - **1976**---NASA's "Viking" **soft-lands on Mars**, marking the US bicentennial.
- **1977**--The S3-3 satellite of the U.S. Air Force observes the upward acceleration of O⁺ ions, related to the downward acceleration of electrons in the polar aurora.
- **1981**--High resolution images are obtained by Lou Frank's group in Iowa of the entire auroral zone, using the Dynamics Explorer satellite.
 - **1981**---**AIDS** begins spreading in the US.
- **1983**--ISEE-3 (International Sun-Earth Explorer 3) explores the distant magnetotail, before heading for comet Giacobini-Zinner.
- **1985**--An "artificial comet" is produced by a cloud of barium ions, released by the German IRM (Ion Release Module) satellite, part of the AMPTE mission. Meanwhile another AMPTE spacecraft, CCE (Charge Composition Explorer) observes mass and energy distribution in the ring current, including its peak energies around 65 keV.
- **1991**--Severe solar-produced shock wave hits the magnetosphere, producing an additional (temporary) inner radiation belt.
- **2004**--the [HESS telescope array](#) in Namibia maps a circular source of high-energy gamma rays, evidence for the origin of cosmic rays in supernovas.
- **27 December 2004**--a [powerful gamma ray burst](#) arrives, apparently from a "magnetar" in our own galaxy.
- **16 December 2004**--Voyager 1 apparently crosses the [termination shock](#) of the solar wind, at which it slows down below the Alfvén speed (magnetic equivalent to sound velocity). That shock is the first sign of resistance to the solar wind by the interstellar plasma.

Author and Curator: [Dr. David P. Stern](#)

Mail to Dr.Stern: [**education\("at" symbol\)phy6.org**](mailto:education@phy6.org)

Co-author: [Dr. Mauricio Peredo](#)

Spanish translation by [J. Méndez](#)

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