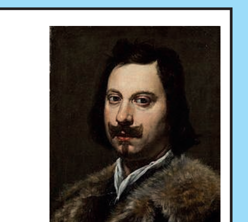
TIMELINE OF THE GAS DISCHARGE PHYSICS

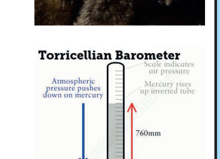
by Julia Cipo & Holger Kersten

Evangelista Torricelli

** October 15th, 1608 in Faenza, Italy*
† October 25th, 1647 in Florence, Italy



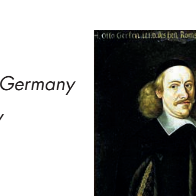
- italian physicist, mathematician and assistant of Galileo Galilei
- invents the Torricelli law in fluid dynamics, where he describes the dependence of the fluid speed from the height of the fluid in a vessel
- invents the first mercury barometer in **1644**, which would later serve for gas discharge observations
- the old pressure unit Torr ist named after him (1 Torr = 1 mm Hg)



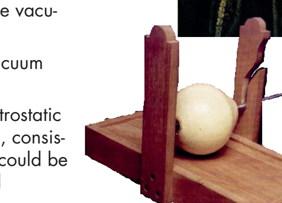
Portrait painted by Lorenzo Lippi, 1647, Now placed at the Gallery Silvano Lodi & Due, -internetdict.com

Otto von Guericke

** November 30th, 1602 in Magdeburg, Germany*
† May 21st, 1686 in Hamburg, Germany



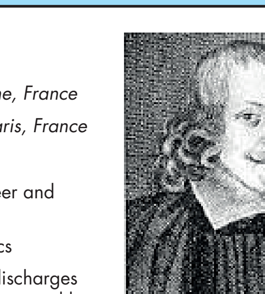
- german physicist, inventor, politician and one of the founders of the vacuum technology
- invents in 1649 the piston vacuum pump
- invents in **1663** the first electrostatic generator: a friction machine, consisting of a sulfur globe, which could be rotated and rubbed by hand



Portrait by the artist Anselm von Hulle, -uni-ulm.de

Jean Picard

**July 21st, 1620 in La Flèche, France*
† October 12th, 1682 in Paris, France

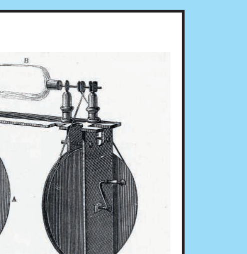


- french astronomer, engineer and priest
- measures the meridian arcs
- observes in **1675** glow discharges on the mercury barometer caused by friction between the mercury and the glass particles
- founder of the first nautical almanac "Connaissance des temps" in 1679

Wikimedia

Francis Hauksbee

**1666 in Colchester, Great Britain*
† April/ May 1713 in London



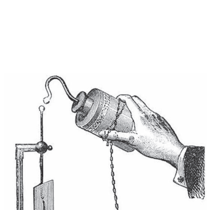
- british scientist, lab assistant of Isaac Newton, member of the Royal Society
- modifies the electric machine by using a glass vessel instead of a sulfur vessel. He reduces the air pressure inside the vessel even more and fills it with mercury
- during the period **1705-1709** he was the first to study the glowing gas discharge inside the glass vessel of an electric machine

Alchetron- Free Social Encyclopedia

Ewald Georg von Kleist

** June 10th, 1700 in Wicewo, Poland*
† December 11th, 1748 in Koszalin, Poland

- german jurist, scientist and cleric
- invents independently in October **1745** the Kleistian jar, which worked on the same principle as the Leyden jar
- forgets to mention the grounding on the description of his experiment, which would make his discovery technically not functionable, so that van Musschenbroek remains the inventor of the first capacitor

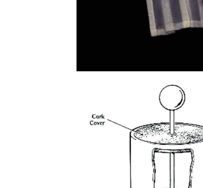


dullophob.info

Pieter van Musschenbroek

** March 14th, 1692 in Leiden, Netherlands*
† September 19th, 1761 in Leiden

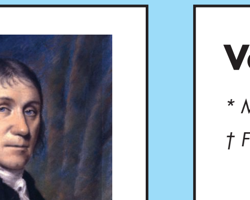
- dutch scientist, a student of Isaac Newton, a friend of Daniel Gabriel Fahrenheit and a fellow of the Royal Society
- inventor of the first capacitor in **1746**, called the "Leyden jar", which was later used by Benjamin Franklin for his kite experiment
- the Leyden jars can save the static electricity in the glass part of the vessel. While grounding the jar, a sparking discharge between the metal layers can be achieved



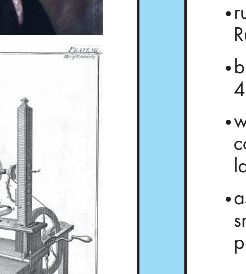
Portrait: de.academic.ru, Leyden Jar Engineering Search Engine http://emadric.blogspot.de/

Joseph Priestley

** March 24th, 1733 in Yorkshire, Great Britain*
† February 6th,1804 in Pennsylvania



- english theologian, chemist, natural philosopher, friend of Benjamin Franklin and member of the Royal Society
- improves the electric machine and discovered the conductivity of charcoal
- notices that the discharge of an electrified body did not acquire direct contact to conductors; the proximity of an conductors would be enough
- summarizes his results in his book "The History and Present State of Electricity" published in **1767**

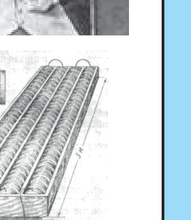


Portrait: Scan of a print found in Wikimedia. Original is housed at the National Portrait Gallery, London, Electrical machine: Medical Historical Library of Yale University

Vasily Vladimirovich Petrov

** March 24th, 1733 in Yorkshire, Great Britain*
† February 6th,1804 in Pennsylvania

- russian physicist and member of the Russian Academy of Sciences
- builds the first large battery, including 4200 serial connected electric cells
- was the first to observe in **1803** a continuous arc discharge by using his large battery
- assumed the use of voltaic batteries in smelting, welding and producing of pure metallic oxides

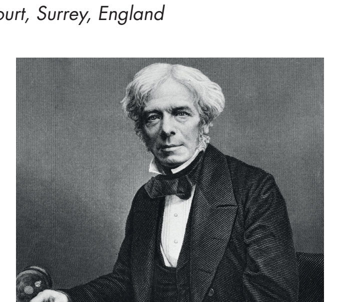


Portrait: rus-eng.org • Petrov's Battery. "Cathodic Arcs: From Fractal Spots to energetic Condensation" by André Anders

Michael Faraday

** September 22nd, 1791 in Newington Butts, Surrey, England*
† August 25th, 1867 in Hampton Court, Surrey, England

- english scientist and inventor, assistant of Humphry Davy and member of the Royal Society
- invents the terms 'anode' and 'cathode'
- investigates the electric current in thinned gases in the period **1831-1835**
- notices the dark space between the negative glow and the positive column, now known as the "Faraday dark space"

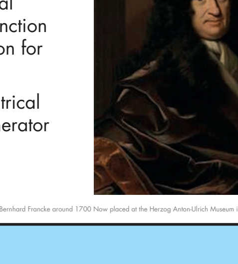


1640 | 1660 | 1680 | 1700 | 1720 | 1740 | 1760 | 1780 | 1800 | 1820

Gottfried Wilhelm von Leibniz

** July 1st, 1646 in Leipzig, Germany*
† November 14th, 1716 in Hannover, Germany

- german mathematician, philosopher, diplomat, historian and a friend of Christiaan Huygens
- inventor of different mathematical laws, like the product rule for function derivation or the Leibniz' criterion for the convergence of a serie
- generates in **1671** the first electrical spark using the electrostatic generator of Guericke

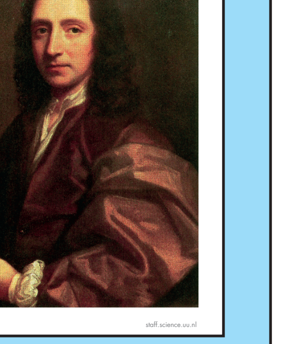


Portrait painted by Christoph Bernhard Francke around 1700 Now placed at the Herzog Anton-Ulrich Museum in Braunschweig, Germany

Edmond Halley

**November 8th, 1656 in Haggerston, London*
† January 25th, 1742 in Greenwich

- british astrophysicist, meteorologist, mathematician and member of the Royal Society
- discovers the line profile of the Earth' magnetic field and the barometric height formula
- notices in **1716** that the arc of the aurora borealis courses along the magnetic pole and not along the geographic arc

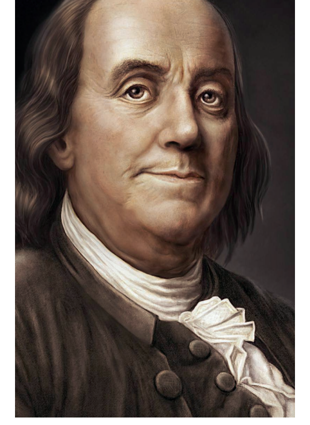


staff.science.uu.nl

Benjamin Franklin

**January 17th, 1706 on the Governor's Island, Boston*
† April 17th, 1790 in Philadelphia, Pennsylvania

- american politician, scientist, printer and co-author of the Independence Declaration of the U.S.A.
- identifies the lightning as electric sparks, a form of electrical discharge
- experiments with lightnings by extracting sparks from the clouds
- invents in **1753** the lightning rod as a protective measure for buildings
- uses the terms 'positive' and 'negative' to describe charges

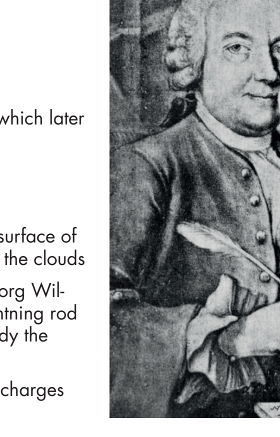


Portrait: Axia Public Relations, Kite Exp: likesuccess.com

Mikhail Vasilyevich Lomonosov

** November 19th, 1711 in a village in Arkhangelsk, Russia*
† April 15th, 1765 in St. Petersburg, Russia

- russian scientist, writer and friend of Leonhard Euler
- invents the "Law of Mass Conservation" in chemistry in 1748, which later would be complemented by Antoine Lavoiser
- explains the formation of icebergs in 1760
- the first to start investigations in atmospheric electricity
- assumes the existence of the electrical charges not only on the surface of the thunderstorm clouds as supposed till then, but also inside of the clouds
- constructs in the **1750s** together with the german physicist Georg Wilhelm Richmann "the thunder machine" which consisted of a lightning rod connected with an electroscope and with its help they could study the lightning sparks
- recognizes the similarity between the auroras and electrical discharges as well as the location of auroras in the upper atmosphere



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Georg Lichtenberg

** July 1st, 1742 in Ober-Ramstadt, Germany, † February 24th, 1799 in Göttingen, Germany*

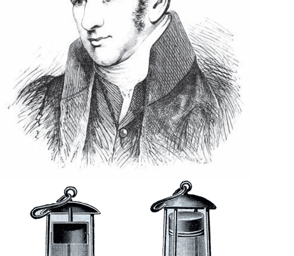
- german mathematician, natural scientist, member of the Royal Society and the first german professor for experimental physics
- was among the first ones to bring the Franklin' lightning rod to Germany
- used and improved the influence machines for his experiments instead of the friction electrostatic generators
- studies the patterns left from an electrical discharge on an insulated surface such as glass; the patterns are known as the Lichtenberg figures
- he notices the dependence of the length of the branchings from the applied voltage or the surrounding air pressure
- publishes **1777** his results in his memoirs „Super Nova Methodo Naturam ac Motum Fluidi Electrici Investigandi"

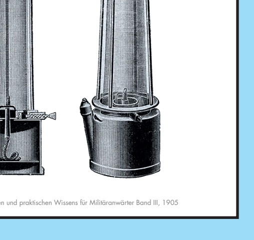
Portrait: uni-goettingen.de | Georg-August-University of Göttingen, Germany| • Lichtenberg Figures: scientificsonline.com

Humphry Davy

** December 17th, 1778 in Penzance, Cornwall in England*
† May 29th, 1829 in Genf, Switzerland

- english chemist and inventor, friend of the french physicist André-Marie Ampère and president of the Royal Society
- constructs a larger voltaic battery with an electrode area of 80 m^2
- presents in **1807** his results on experiments with electrolytes with the purpose to gain pure metals and gases
- notices glowing continuous arcs using his battery for melting electrolysis
- invents the Davy lamp with methane, which was used as a safety lamp for workers in the coal mines
- invents the carbon arc lamp in **1807**





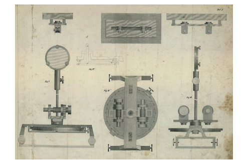
Portrait: Popular Science Monthly Volume 14 • Davy's Battery: Bibliothek allgemeinen und praktischen Wissens für Militäranwärter Band III, 1905

Carl Friedrich Gauss

** April 30th, 1777 in Braunschweig, Germany*

† February 23rd, 1855 in Göttingen, Germany

- german mathematician, astronomer, physicist and a student of Georg Christoph Lichtenberg
- invents a lot of mathematical computational methods and studies the Earth's magnetic field
- constructs in 1832 the magnetometer to measure the daily fluctuations of the magnetic field for a sustained period between **1836-1841**
- explains the fluctuations as a consequence of electrical discharges happening in a conductive layer of the atmosphere. An example that confirms his theory is the phenomena of Auroras



Portrait: www.gauss-goettingen.de • Magnetometer: Niedersächsische Staats- und Universitätsbibliothek Göttingen

Ernst Werner von Siemens

** December 13th, 1816 in Lenthe by Hannover, Germany*

† December 6th, 1892 in Berlin, Germany

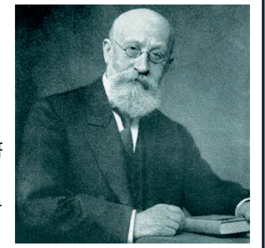
- german inventor, industrialist and founder of the electrical company Siemens
- invents the ozone generator in **1857**
- recognizes a glowing discharge while high voltage has been applied to the air inside the glass tubes of the ozone generators
- notices the disinfectant effect of ozone, which is the reason of using the ozone generator in water cleaning processes
- among the firsts to use the arc-lamps as streetlights in March **1879**

Portrait: Siemens.com • Ozoniser: The Hellenic Archives of Scientific Instruments

Gotthilf-Eugen Goldstein

** September 5th, 1850 in Gleiwitz, Germany*

† December 25th, 1930 in Berlin, Germany



- german physicist, student and friend of Hermann von Helmholtz
- names the cathode rays discovered by Hittorf because of their source: the cathode
- realizes the perpendicular emission of the cathode rays to the cathode surface in **1876**
- discovers the anode rays in **1886**, which were generated by positively charged particles and had the opposite propagation direction as the cathode rays
- names the discovered anode rays "the canal rays" because they pass through the channels in the cathode

Portrait : Biografias y vidas- La Enciclopedia Biográfica en Línea

Sir Joseph John Thomson

** December 18th, 1856 in Cheetham Hill, Manchester in England*

† August 30th, 1940 in Cambridge, England

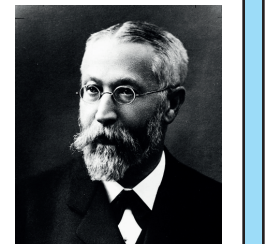
- english physicist, president of the Royal Society, the teacher of Ernest Rutherford
- winner of the Nobel Prize in physics in 1906 for his researches on the conductivity of gases
- recognizes that all the cathode rays have the same origin: they consist of particles with the same negative charge
- he discovers in **1897** the negative charged electrons by calculating the mass-to-charge-ratio
- calculates the electron's mass and obtains a value about 1/2000 of the mass of the hydrogen atom

Portrait: Popular Science Monthly Volume 73, 1908 • Deflection of cathode rays: OpenStax CNX by the Rice University, U.S.A

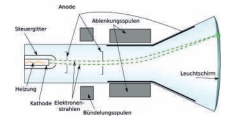
Karl Ferdinand Braun

** June 6th, 1850 in Fulda, Germany*

† April 20th, 1918 in New York, USA



- german physicist and electrical engineer
- winner of the Nobel Prize in physics in 1909 for his work on the wireless telegraphy
- develops the Braun' tubes in **1897**, an improved cathode discharge tube with an integrated Wehnelt cylinder
- 14.12.1930 the Braun' tubes became the basis for the first tube televisions

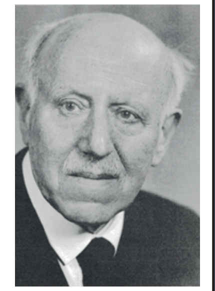


Portrait: Nobelprize.org • Braun Tube: ph2.physik.uni-goettingen.de

Rudolf Seeliger

** November 12th, 1886 in München, Germany*

† January 20th, 1965 in Greifswald, Germany



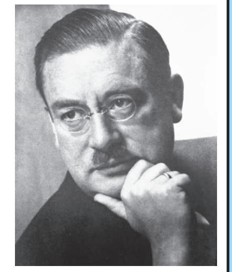
- german physicist, student of Arnold Sommerfeld and a colleague of Johannes Stark
- notices in 1912 while experimenting, that the needed energy for the excitation of spectral lines through a current flow is portioned – the predecessor of the Franck-Hertz experiment
- establishes the "Institute for gas discharge physics" in Greifswald, now known as the "Institute for Low Temperature Plasma Physics" (INP)

Portrait: Leibniz Institut für Plasmaforschung und Technologie e.V. Greifswald (Leibniz Institute for Plasma Science and Technology in Greifswald)

Peter Debye

** March 24th, 1884 in Maastricht, Netherlands*

† November 2nd, 1966 in Ithaca, New York, U.S.A



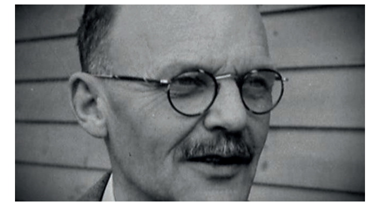
- dutch-american chemist, physicist and a student of Arnold Sommerfeld
- winner of the Nobel Prize in chemistry in 1936 "for his contributions to the study of molecular structure"
- achievements **1927** in electrochemistry, which could be conferred in plasmas as for example the characteristic Debye length referred to the shielding process in plasmas by entrance of a test particle
- defines the ideal plasmas as spheric medium with a high concentration of electrons

Portrait: Sächsische Akademie der Wissenschaften zu Leipzig (Saxon Academy of Sciences in Leipzig)

Johannes "Hans" Wilhelm Geiger

** September 30th, 1882 in Neustadt an der Haardt, Germany*

† September 24th, 1945 in Potsdam, Germany



- german physicist, who worked together with Ernest Rutherford and James Chadwick
- constructs in **1928** the Geiger-Müller counter, a device for measuring the ionising radiation
- the Geiger counter works based on the Townsend discharge, a dark gas discharge, which leads to an avalanche effect in the production of electrons

Portrait: SWR (SüdWestRundfunk) Fernsehen Online - (South West Broadcast)TV Online

Hannes Olof Gösta Alfven

** May 30th, 1908 in Norrköping, Sweden*

† April 2nd, 1995 in Djursholm, Sweden

- swedish physicist, a colleague of Ernest Rutherford, pioneer of the plasma physics, member of the Royal Swedish Academy, the European Physical Society and foreign member of the Yugoslav, U.S. and Soviet Academies of Sciences
- winner of the Nobel Prize in physics in 1970 "for fundamental work and discoveries in magneto-hydrodynamics with fruitful applications in different parts of plasma physics"
- publishes his theory on the formation of the auroras in his book "Cosmical Electrodynamics" in **1950**
- explains, that the flux of plasma around the magnetic dipole field of the Earth causes electric currents that lead to the aurora glowing discharges
- supposes in 1942 the existence of electro-hydrodynamic waves, called the "Alfvén waves"
- opens a new branch of plasma physics, called the "magnetohydrodynamics"

Portrait: Techmania Science Center

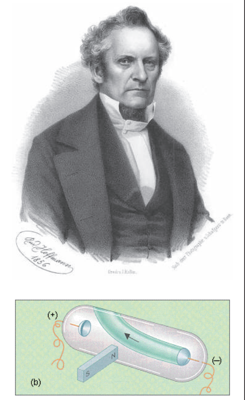
1938: Plasma lamps are available for the normal costumer
1953: Robert M.Gage invents the plasma arc welding and cutting process, which achieved precision on both thin and thick metals
1960: The first gas laser (Helium-Neon- laser) is invented by the iranian-american physicist Ali Javan and the american scientist William R.Bennett, Jr.
1992: First Deuterium-Tritium discharges in the JET (Joint European Torus) fusion reactor
2000s: More than 200 companies in Germany working in the sector of low temperature plasmas
2007: The foundation of the large international experimental fusion reactor ITER

1840 | **1860** | **1880** | **1900** | **1920** | **1940** | **1960** | **1980** | **2000**

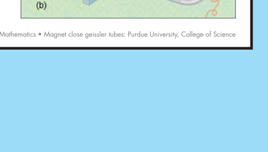
Julius Plücker

** June 16th, 1801 in Elberfeld by Wuppertal, Germany*

† May 22nd, 1868 in Bonn, Germany



- german mathematician, physicist and foreign member of the Royal Society
- the first to use the geissler tubes, since Heinrich Geissler was his glassblower
- lays the foundation for the vacuum engineering, since the geissler tubes were the first ones with good vacuum conditions
- recognizes the deflection of the glowing rays by approximating a magnet to the geissler tube in **1858**. So he discovers the electrical properties of discharges
- notices in 1862 the different spectra of the same gas. He is the first to observe the three lines of the hydrogen spectrum

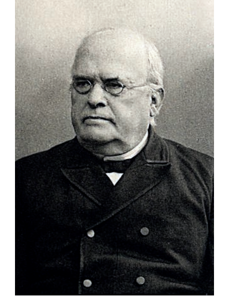


Portrait: Hausdorff Center for Mathematics • Magnet close geissler tubes: Purdue University, College of Science

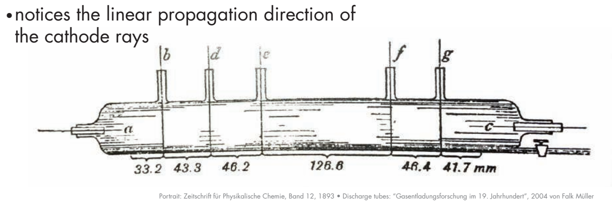
Johann Wilhelm Hittorf

** March 17th, 1824 in Bonn, Germany*

† November 28th, 1914 in Münster, Germany



- german physicist, chemist, a student and assistant of Julius Plücker as well as the teacher of Friedrich Paschen
- works with thinned gases as well as Faraday did and adds potential probes to the gas discharge tubes to measure the electrostatic field
- discovers the cathode rays in **1869** or as he refers to "the rays of the negative light from the cathode to the anode"
- notices the linear propagation direction of the cathode rays

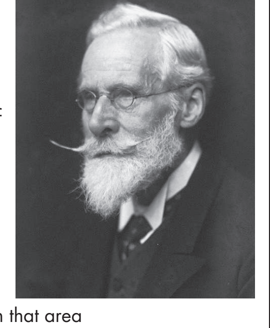


Portrait: Zeitschrift für Physikalische Chemie, Band 12, 1893 • Discharge tubes: "Gasentladungsforschung im 19. Jahrhundert", 2004 von Falk Müller

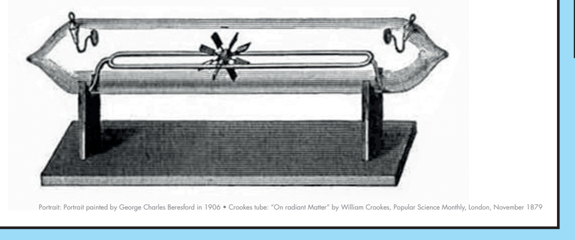
Sir William Crookes

** June 17th, 1832 in London, England*

† April 4th, 1919 in London, England



- english physicist, chemist and member of the Royal Society
- improves the vacuum properties of the geissler tubes by reducing the gas pressure from 10^{-3}atm to 10^{-8}atm
- names the dark space next to the cathode "the Crookes dark space" and explains its formation due to a lower collision rate of electrons with the gas atoms in that area
- designs the Crookes tubes: new shaped discharge tubes with different shapes of the anode in the **1870s**
- approves Hittorf's result on the linear propagation of the cathode rays
- notices the heating effect of the cathode rays
- explains the glowing discharge in the Crookes tubes with the existence of "a fourth state of matter"

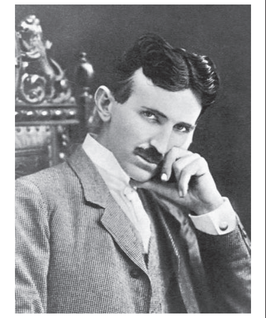


Portrait: Portrait painted by George Charles Beresford in 1906 • Crookes tube: "On radiant Matter" by William Crookes, Popular Science Monthly, London, November 1879

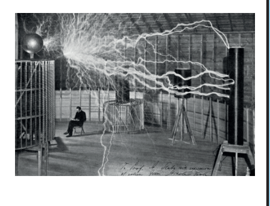
Nikola Tesla

** July 10th, 1856 in Smiljan, Croatia*

† January 7th, 1943 in New York, USA



- serbian-american inventor, electrical engineer and physicist
- the first to invent an alternating current system, replacing the weak direct current generators and motors
- patents in **1891** the "Tesla coil", a high-frequency transformer, which could generate large corona discharges
- experiments with geissler tubes and generates glow discharges inside of them by placing them cordless right in the middle of an oscillating electric field
- improves the arc-lamp in 1891 by adding an alternator to suppress the loud generated sound

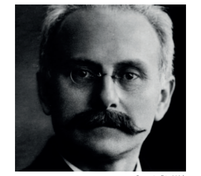


Portrait: Focus Online • Discharge: Spiegel Online

Johannes Stark

** April 15th, 1874 in Schickenhof by Freihung, Germany*

† June 25th, 1957 in Gut Eppenstatt by Traunstein, Germany



Portrait: Die Welt

- german physicist and representative of the nationalism in Germany
- winner of the Nobel Prize in physics in 1921 for the discovery and explanation of the Stark Effect as a splitting effect of the spectral lines in electric fields
- discovers in **1905** the optical Doppler effect in canal rays

Clement Dexter Child

** 1868 in Madison, Ohio, USA*

† July 15th, 1933 in Rochester, New York, USA

- american physicist and colleague of J.J.Thomson and I. Langmuir
- studies gas discharges while using a heated cathode, which causes the thermionic emission of electrons
- notices a current limitation after the emission, explaining it with the existence of a space charge
- presents in 1913 the "Child-Langmuir Law" as a correlation between the voltage and the current between two electrodes in vacuum

Sir John Sealy Edward Townsend

** June 7th, 1868 in Galway, Ireland*

† February 16th, 1957 in Oxford, England

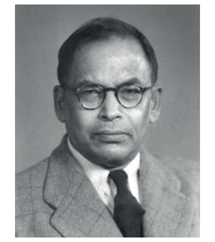
- irish mathematician, physicist, fellow of the Royal Society and a student of J.J.Thomson
- explains in **1915** in his book "Electricity in Gases" the dark/Townsend discharges referring to an "electron avalanche effect" caused by a multiplied emission through collision of free electrons with gas atoms
- establishes the "Townsend Ionisation Coefficients" which express the number of anions or cations per unit length during the dark discharge

Portrait: Biographical Memoirs of Fellows of the Royal Society Vol. 3 (Nov., 1957) by A. von Engel

Meghnad Saha

** October 6th, 1893 in Shaoratoli by Dhaka, British India*

† February 16th, 1956 in Delphi, India



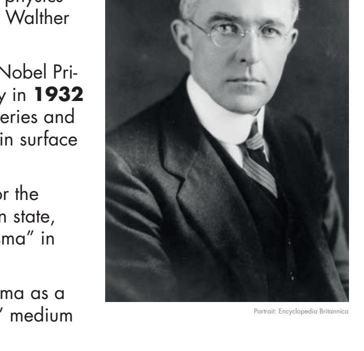
- indian astrophysicist, politician, fellow of the Royal Society and a classmate of the famous physicist Satyendra Nath Bose
- prepares in 1919 together with Bose the first recorded english translation of Einstein's "Theory of Relativity"
- presents in **1920** on his paper "On the Ionization of the Solar Chromosphere" his greatest discovery: "the Saha-Eggert equation", a formula for the determination of the ionization level in gases
- helps building the first cyclotron in his country

Portrait: Ramakrishna Mission Calcutta Students Home

Irving Langmuir

** January 31st, 1881 in Brooklyn, New York*

† August 16th, 1957 in Woods Hole, Massachusetts, USA



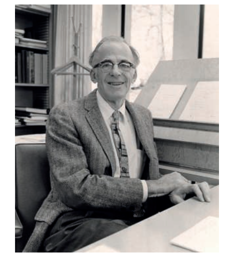
- american physicist and chemist, a pioneer of the gas discharge physics and student of Walther Nernst
- winner of the Nobel Prize in chemistry in **1932** "for his discoveries and investigations in surface chemistry"
- name finder for the 4. aggregation state, calling it "plasma" in **1927**
- describes plasma as a "quasi-neutral" medium in **1929**
- develops the Langmuir probe in 1924 with the purpose to determine plasma parameters
- discovers the "Langmuir waves" which arise out of the propagation of the oscillations made by the charged particles
- invents a gas-filled light bulb with a better lucency than the vacuum bulbs, that were common at that time

Portrait: Encyclopedia Britannica

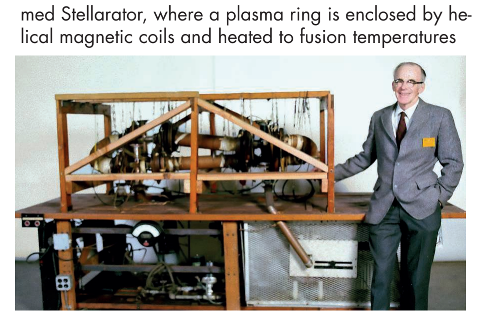
Lyman Spitzer

** June 26th, 1914 in Toledo, Ohio, U.S.A*

† March 31st, 1997 in Princeton, New Jersey, U.S.A.



- american astrophysicist and member of the National Academy of Sciences and of the American Academy of Arts and Sciences
- the first to propose the idea of placing a large telescope in space
- lobbies the NASA to build the Hubble Space Telescope
- constructs in **1951** a thermonuclear fusion reactor named Stellarator, where a plasma ring is enclosed by helical magnetic coils and heated to fusion temperatures



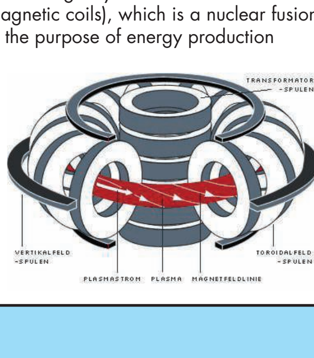
Portrait+Stellarator: Princeton Plasma Physics Laboratory • Portrait: Princeton Weekly Bulletin

Lev Andreevich Artsimovich

** February 25th, 1909 in Moscow, Russia*

† March 1st, 1973 in Moscow, Russia

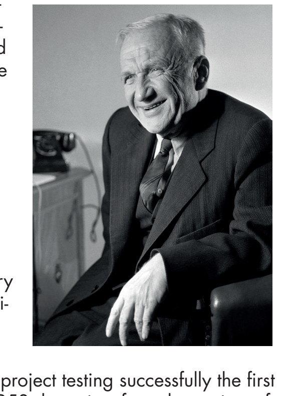
- soviet physicist and member of the Soviet Academy of Sciences as well as foreign member of the American, Yugoslav, Swedish and Czechoslovak Academy of Arts and Sciences
- works on the Soviet atomic bomb project at the Kurchatov Institute
- one of the designers of the Tokamak (**To**roidalnaja **ka**mera w **ma**gnitnych **k**atuschkach = toroidal chamber in magnetic coils), which is a nuclear fusion reactor with the purpose of energy production



Igor Tamm

** July 8th, 1895 in Vladivostok, Russia*

† April 12th, 1971 in Moscow, Russia



- soviet physicist, member of the Soviet Academy of Sciences and foreign member of the American, Polnish, Swedish Academy Arts and Sciences

-winner of the Nobel Prize in physics in 1958 together with Pavel Alekseyevich Cherenkov and Ilya Frank for the discovery of the Cherenkov radiation

-works on the Soviet thermonuclear bomb project testing successfully the first hydrogen bomb in 1953; he retires from the project after that

-one of the designers of the Tokamak

–introduces the principle of the Tokamak together with Artsimovich and Sakharov in 1952

Andrei Sakharov

** May 21st, 1921 in Moscow, Russia*

† December 14th, 1989 in Moscow, Russia

- soviet physicist, member of the Soviet Academy of Sciences, human rights activist and soviet dissident
- winner of the Nobel Peace Prize in 1975
- works for a short time on the Soviet atomic bomb project
- one of the designers of the Tokamak
- presents together with Artsimovich and Tamm the first constructed Tokamak in 1962, which consists of different kinds of magnetic coils surrounding the plasma ring inside

Artsimovich Portrait: eduspb.com • Tamm Portrait: nobelprize.lebedev.ru • Sakharov Portrait: Encyclopedia Britannica • Tokamak: Principle: Max-Planck-Institut für Plasmaphysik