Plasma Universe 2013

99.999% of the visible Universe

www.plasma-universe.com

Image: Nebula M1-67 around Star Wr124.
http://hubblesite.org/gallery/album/star_collection/pr1998038a/
Credit: Yves Grosdidier (University of Montreal and Observatoire de Strasbourg), Anthony Moffat (Universitie de Montreal), Gilles Joncas (Universite Laval), Agnes Acker (Observatoire de Strasbourg), and NASA

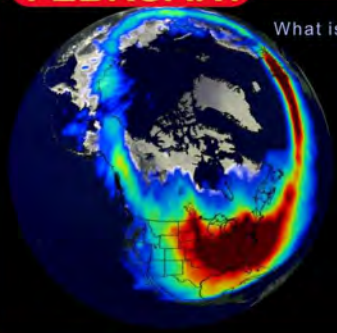
COVER

JANUARY

99.999% Plasma

FEBRUARY

What is Plasma?



MARCH

Why is Plasma s

APRIL

Electrified Plasma

MAY

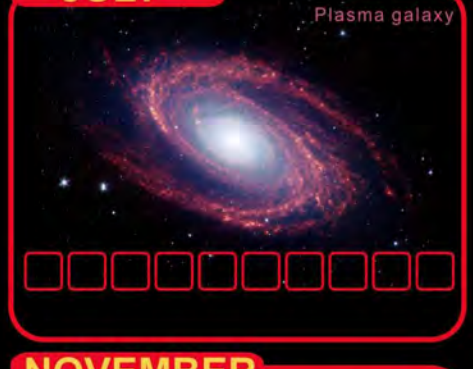
Pinched Plasma filamen

JUNE

Plasma focus

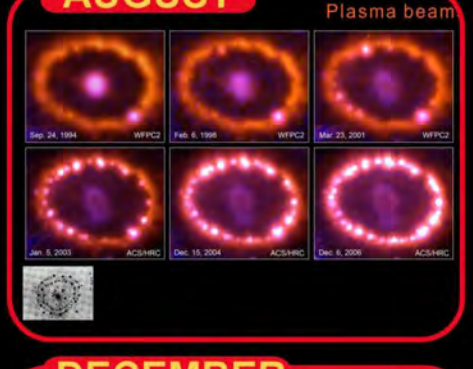
JULY

Plasma galaxy



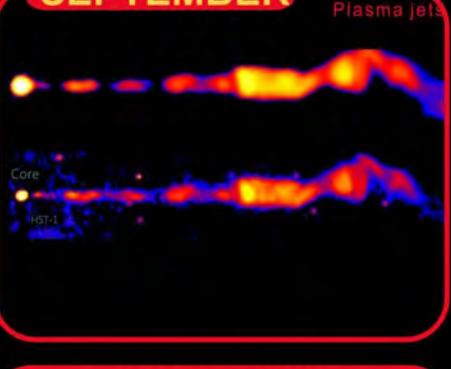
AUGUST

Plasma beam



SEPTEMBER

Plasma jets



OCTOBER

Plasma sun

NOVEMBER

Plasma rings

DECEMBER

Plasma generato

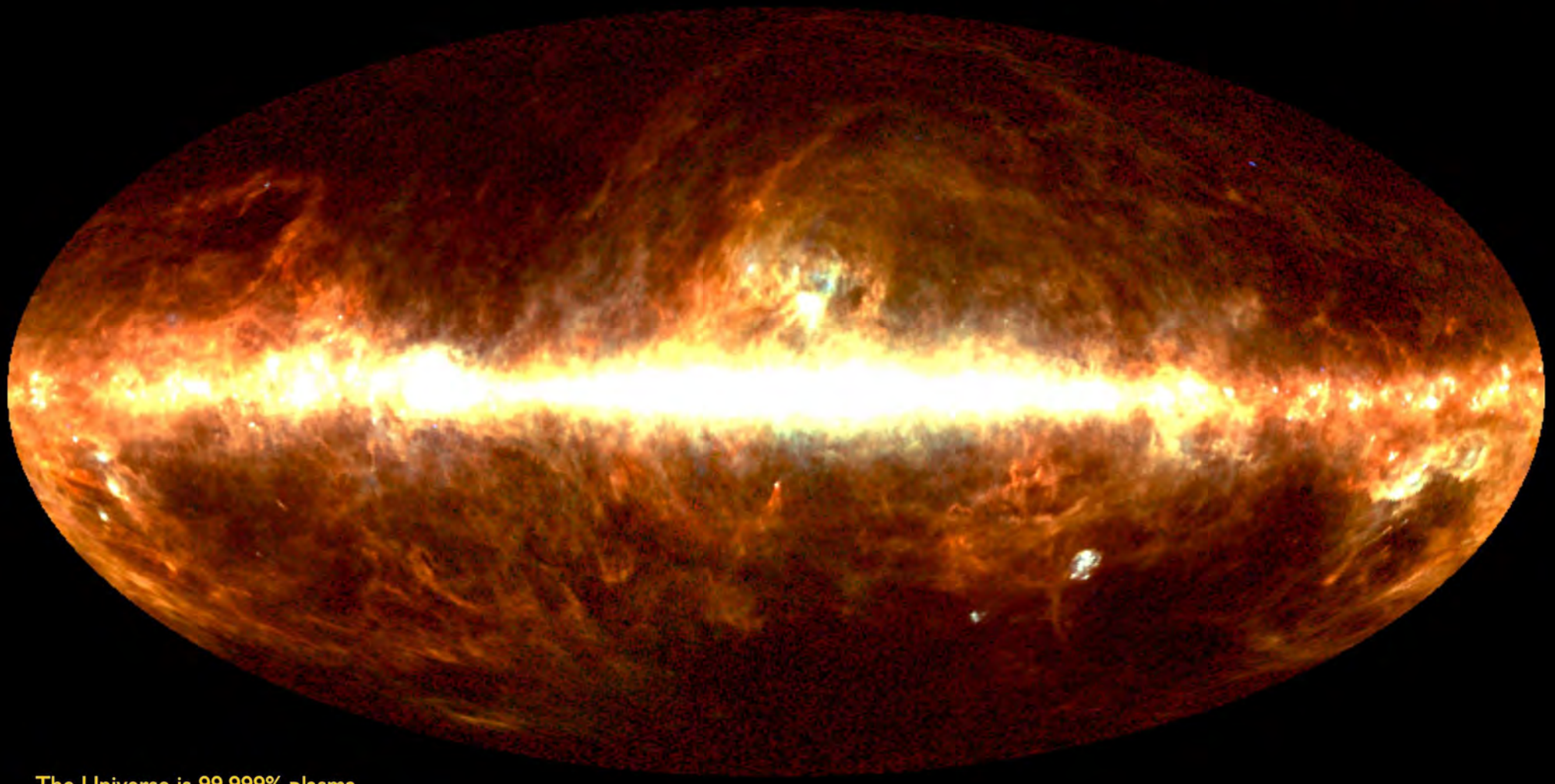
Plasma Universe pioneers

www.
plasma-universe
.com

D E C E M B E R 2 0 1 2

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
November 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	January 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	27	28	29	30	1
2	3	4 1931: Carl-Gunne Fälthammar, plasma pioneer, born	5	6	7	8
9 Hanukkah	10	11 1910: Georges Claude displays the first neon lamp in Paris	12	13 1867: Kristian Birkeland, plasma pioneer born Geminids Meteor Shower	14	15
16	17	18 1856: Sir J J Thomson, pioneer born	19	20	21 Winter Solstice	22
23	24 Christmas Eve	25 Christmas Christmas Day	26 Boxing Day Kwanzaa	27	28	29
30 1979: Charles Bruce, electrical engineer, dies	31	1	2	3	4	5

99.999% Plasma



The Universe is 99.999% plasma

Our Sun is very hot and hence nearly entirely **plasma**,...as are all the stars.

The Sun's hot solar wind filling the interplanetary medium (the space between the planets), is a **plasma**.

The interstellar medium (the space between the stars), and the inter-galactic medium (space between galaxies), are nearly all **plasma**.

The Earth's ionosphere, where we see the aurora, is a **plasma**. Dust or gas inside a plasma, behaves as a **plasma**.

Asteroids, comets and planets, are not made of plasma, but solids, liquids and gases...the exception, not the rule.

Image: COBE's Infrared View of the Universe. **Credit:** Michael Hauser (STScI), the COBE/DIRBE Science Team, and NASA. News Release Number: STcI-1998-01
http://hubblesite.org

J A N U A R Y 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	31	1 New Year's Day New Year's Day	2 2nd January (Scotland)	3	4	5
6 The Epiphany	7	8	9	10	11	12
13	14	15	16	17	18	19 1991: Winston H. Bostick, plasma pioneer dies
20	21 Martin Luther King, Jr. Day	22	23	24	25	26
27	28	29	30	31 1881: Irving Langmuir, plasma pioneer born	1	2
3	4	5	6	7		

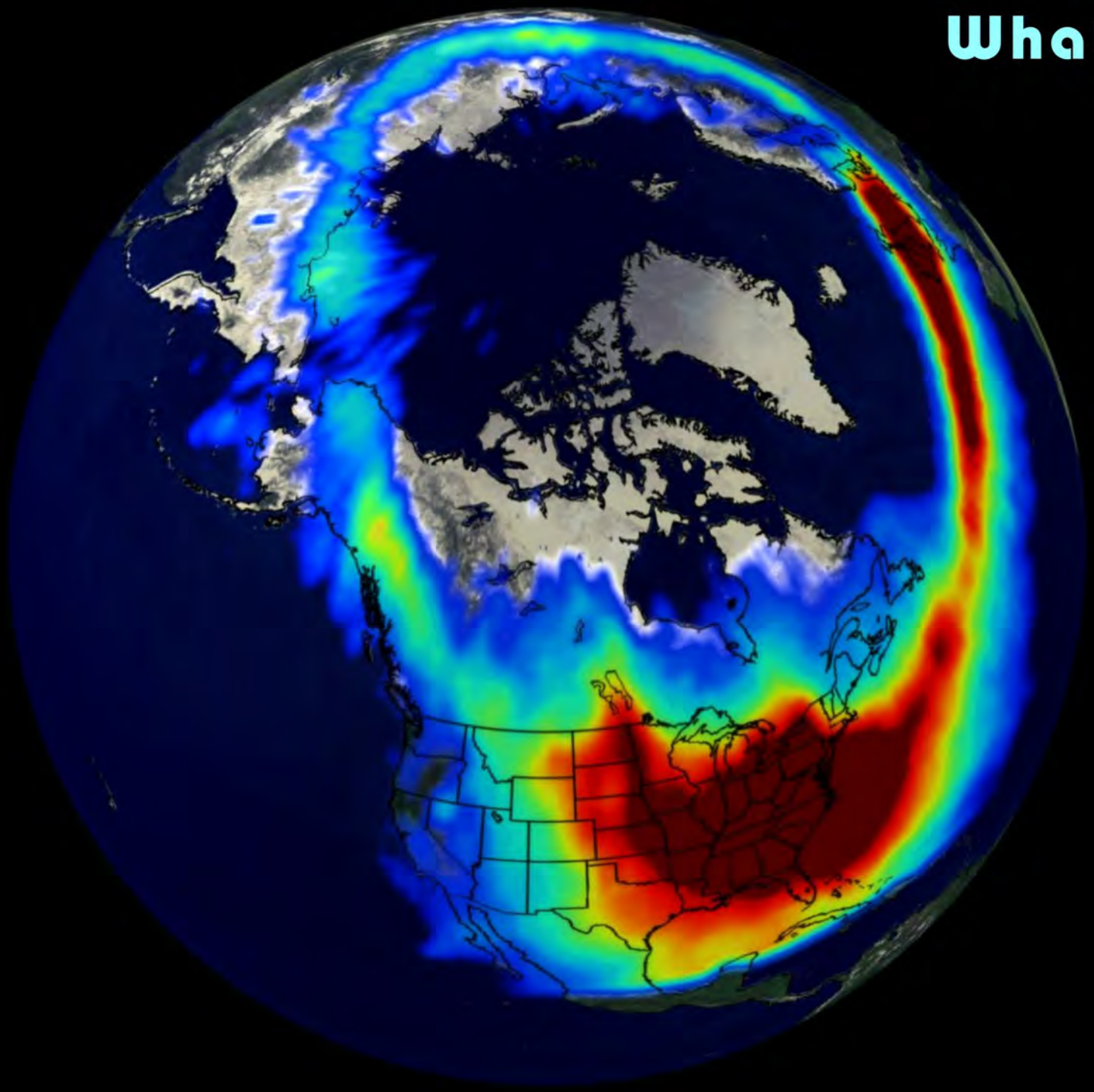
December

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

What is Plasma?



Plasma is a form of matter.

For example, we're familiar with **solids,** such as Greenland's white arctic ice, with **liquids** such as the Earth's blue oceans, and **gases**, such as the windy atmosphere.

Plasma is a mixture of free-moving negatively charged electrons and positive ions (that make up atoms and molecules in other forms of matter). Plasma may also contain neutral atoms, molecules and dust, such as the Earth's ionosphere, in which we see the aurora.

Image: Polar/VIS satellite image of the aurora over the USA, showing Greenland covered in ice, taken on July 16, 2000. Credit: NASA/Goddard Space Flight Center, Scientific Visualization Studio. http://svs.gsfc.nasa.gov/

F E B R U A R Y 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	March 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	29	30	31	1	2 1897: Kristian Birkeland starts 1st (failed) expedition Groundhog Day
3 1925: Oliver Heaviside dies. He reformulated Maxwell's equations	4	5	6	7	8	9
10 Chinese New Year (Year of the Snake)	11	12 Lincoln's Birthday	13 Ash Wednesday Ash Wednesday	14 Valentine's Day Valentine's Day	15 1826: George Stoney is born; proposed existence of the electron	16
17 1773: Captain James Cook 1st records & names the Aurora Australis	18 Washington's Birthday President's Day	19	20 1989: First Workshop on Plasma Cosmology, USA	21	22	23
24 Purim	25	26	27	28	1	2
3	4	5	6	7	8	9

Why is Plasma so?

Electro-magnetic forces affect plasmas far more strongly than gravity. For example, solar flares (a plasma) loop, twist and spiral with the Sun's magnetic field, sometimes escaping the Sun's intense gravitational field altogether, and accelerating away as the Solar Wind.

Solar Wind charged particles approaching the Earth's gravitational field are readily deflected by its magnetic field; this magnetosphere helps protect the Earth. Plasma "leaking" into the poles appear as the aurora, but intense solar flares can knock out a city's electric power!

Image: Prediction of Solar Storms in Future, NIX #: MSFC-0201490. Date: 2002-06-01 **Credit:** Steele Hill, Marshall Space Flight Center, NASA URL: http://mix.msfc.nasa.gov/abstracts.php?p=2302

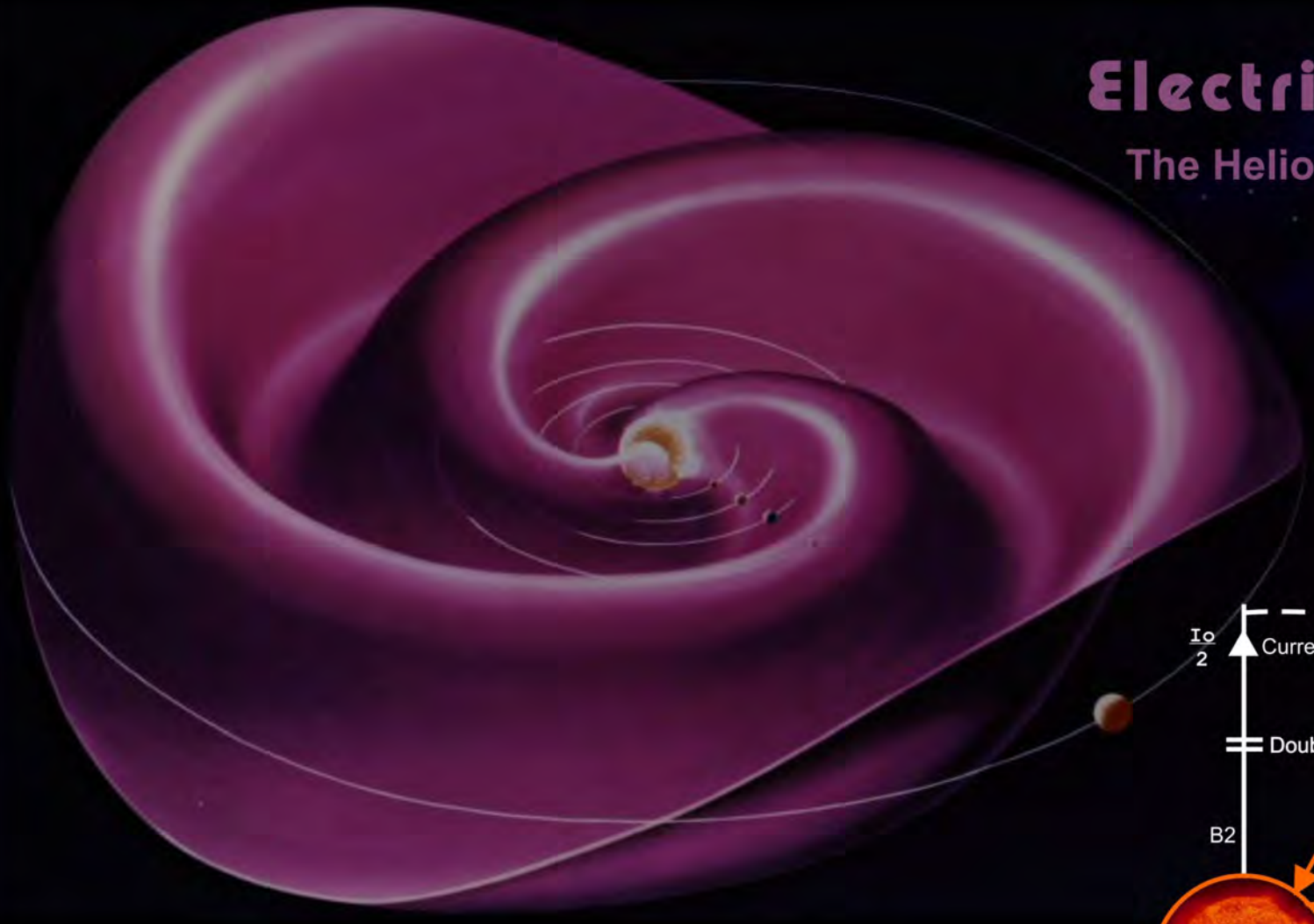
Steele Hill/NASA

M A R C H 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
February 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	April 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	26	27	28	St. David's Day 1	2
3	4	1916: Winston H. Bostick, pioneer born 5	6	7	8	9
Mother's Day Daylight Savings Time Begins 10	11	12	13	14	15	16
St. Patrick's Day St. Patrick's Day (N. Ireland) 17	18	19	11:02 Spring Equinox Spring Equinox 20	21	22	23
Palm Sunday 24	25	Passover 26	27	28	Good Friday Good Friday 29	30
British Summertime Begins Palm Sunday Easter Easter 31	1	2	3	4	5	6

Electrified Plasma

The Heliospheric Current Sheet



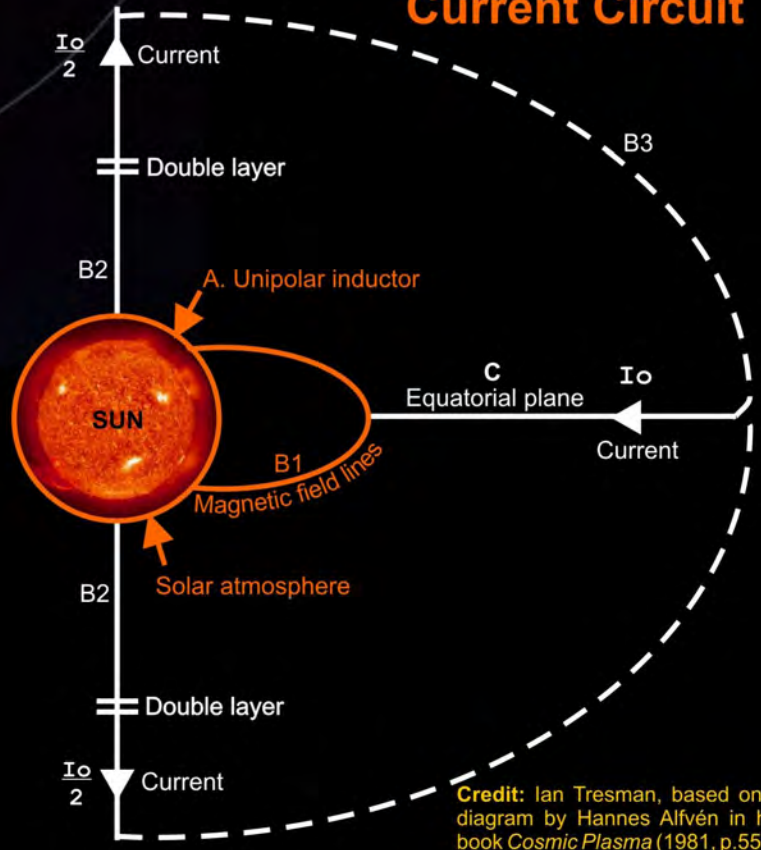
Credit: From an original painting by Werner Heil, NASA, 1977. Image developed by Prof. John Wilcox to help visualize the surface that separates the Sun's two magnetic polarities. Source: Wilcox Solar Observatory, http://wso.stanford.edu/

The heliospheric current sheet is the largest structure in the Solar System extending from the Sun and out to the heliopause, through the ecliptic in the plane of the Solar System.

Its shape results from the interaction of the Sun's rotating magnetic field with the moving Solar Wind plasma (interplanetary medium), and is sometimes likened to a ballerina's skirt.

Carrying three trillion Amps, the sheet has been described by an electric circuit (right).

The Heliospheric Current Circuit



Credit: Ian Tresman, based on a diagram by Hannes Alfvén in his book *Cosmic Plasma* (1981, p.55).

A P R I L 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31	1 Easter Monday April Fool's Day April Fool's Day	2 1995: Hannes Alfvén, pioneer dies	3	4 1919: Sir William Crookes, pioneer dies	5	6
7	8	9	10	11	12	13
14	15 Tax Day	16	17	18	19	20
21 Queen's Birthday	22 Earth Day	23 St. George's Day	24	25	26	27
28	29	30 1897: J.J. Thomson identifies "radiant matter"	1	2	3	4
5	6	7	8	9		

March

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

May

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Pinched Plasma filaments

Middle image: The Ant nebula (Mz3), NASA, Space Telescope Science Institute, http://photojournal.jpl.nasa.gov/catalog/pia04216

Lower image: Pinched aluminium can, produced from a pulsed magnetic field created by rapidly discharging 2 kilojoules from a high voltage capacitor bank into a 3-turn coil of heavy gauge wire. Credit: Bert Hickman, Stoneridge Engineering: www.teslamania.com

Filamentary structure is one of the main characteristics of electrified plasma, which is produced by constricting magnetic fields. They are seen in lightning bolts, the aurora, the Sun and nebulae (eg. the Ant Nebula above)

If the magnetic field becomes much stronger along one part of the filament than another, it **pinches** producing a characteristic hour-glass shape. The drinks can (left) was made this way.

Filaments often twist into helical shapes, and are sometimes called **Birkeland currents**.

M A Y 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
28	29	30	1	2	3	4 1937: Hannes Alfvén predicts intergalactic magnetic field
Cinco de Mayo 5	Early May Bank Holiday 6	7	8	9	1993: 2nd Plasma Astrophysics and Cosmology Workshop 10	11
Mother's Day 12	13	1937: Hannes Alfvén predicts an interstellar and intergalactic magnetic field 14	15	16	17	Armed Forces Day 1850: Oliver Heaviside born. He reformulated Maxwell's equations 18
19	20	21	22	1960: Georges Claude dies. In 1910 he displayed the first neon lamp 23	24	25
1814: Johann Geissler born, inventor discharge tube 26	Spring Bank Holiday Memorial Day 27	28	John F. Kennedy's Birthday 29	1908: Hannes Alfvén, pioneer born 30	31	1
2	3	4	5	6	April 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	June 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Plasma focus

Pairs of vortex filaments can be seen, looking down the tube of a dense plasma focus (above), a laboratory device that **electromagnetically** accelerates hot dense plasma out of a tube.

Plasma physicists may apply such knowledge gained in the **laboratory** to the **cosmos;** note similarities to, for example, the nebulae (left).

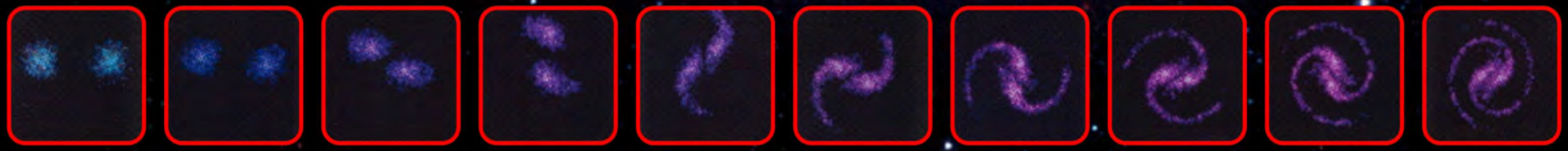
Left: NGC 6751, the Glowing Eye Nebula. **Credit:** NASA, The Hubble Heritage Team (STScI/AURA), http://hubblesite.org/newscenter/archive/releases/2000/12/

Top: radial current filaments flowing from the end of a plasma focus center conductor (3.4 cm diameter) to 10 cm diameter outer conductor. **Source:** Winston H. Bostick

J U N E 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	July 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13 1903: Willard Harrison Bennett, plasma pioneer born 1831: James Clerk Maxwell born	14 Flag Day	15 1917: Kristian Birkeland, pioneer dies
16 ICOPS 2013 Conference San Francisco Father's Day Father's Day	17 1832: Sir William Crookes, pioneer born	18	19	20	21 Summer Solstice (05:45) Summer Solstice 5:04 Summer Solstice	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

Plasma galaxy



A galaxy's stars are all plasma, and much of the interstellar space between them. Several theories describe their shape, such as spiral galaxy M81 above.

Plasma physicists have simulated galaxy formation as plasma clouds inside interacting parallel current-carrying magnetic filaments (bottom row).

Top: M81 spiral galaxy taken with the Spitzer Space Telescope **Credit:** NASA/JPL-Caltech/S. Willner. http://www.spitzer.caltech.edu/Media/releases/ssc2003-06/ssc2003-06c.shtml

Lower image: Interacting Birkeland currents carrying 10^{18} Amps, length 80kpc width 35kpc, over 10^{9} years. **Credit:** Anthony L. Peratt, http://www.plasmauniverse.info/

J U L Y 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	1 1902: Kristian Birkeland begins 2nd auroral expedition Canada Day	2	3	4 Independence Day	5 1911: George Johnstone Stoney dies. In 1874 he proposes the existence of the electron Battle of Boyne Day (N. Ireland)	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30 1922: Emil Wolf born. He discovers the Wolf "red" shift	31	1	2	3
4	5	6	7	8		

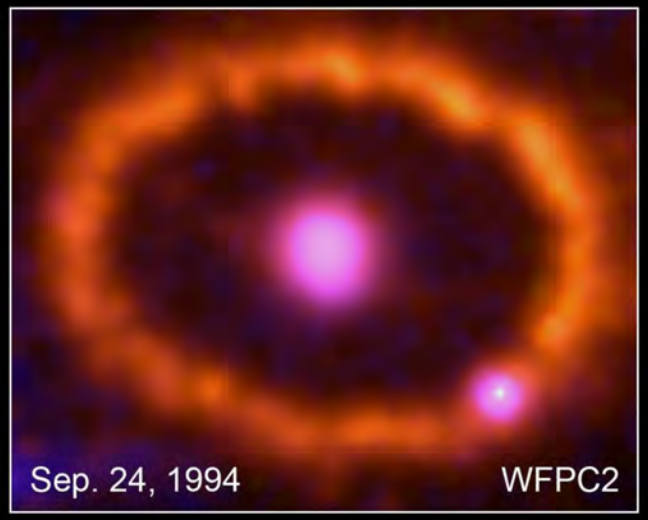
June

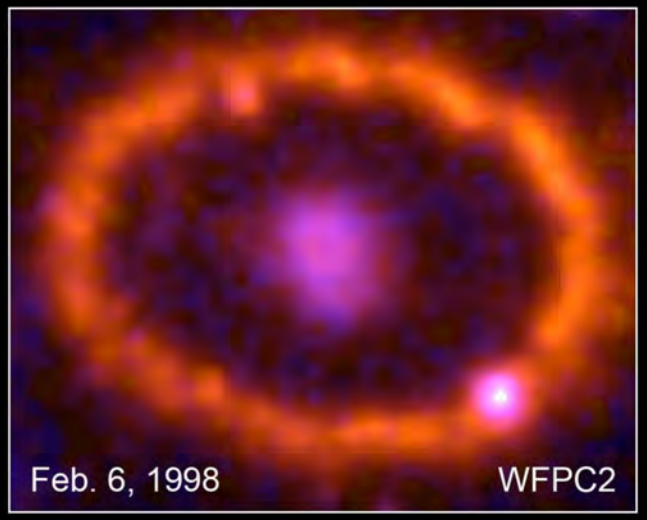
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

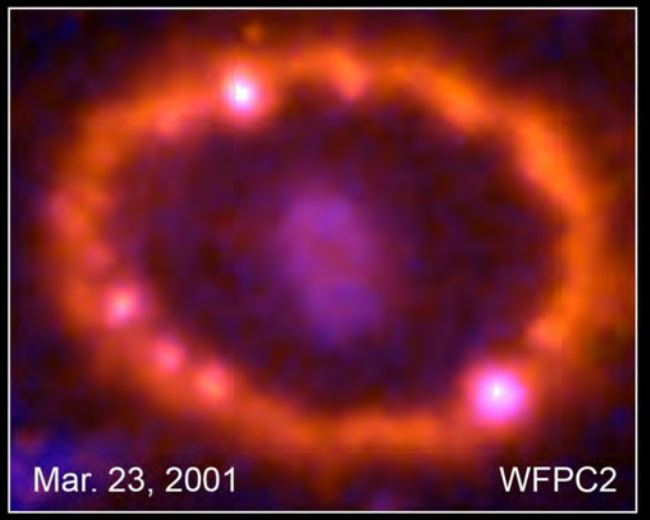
August

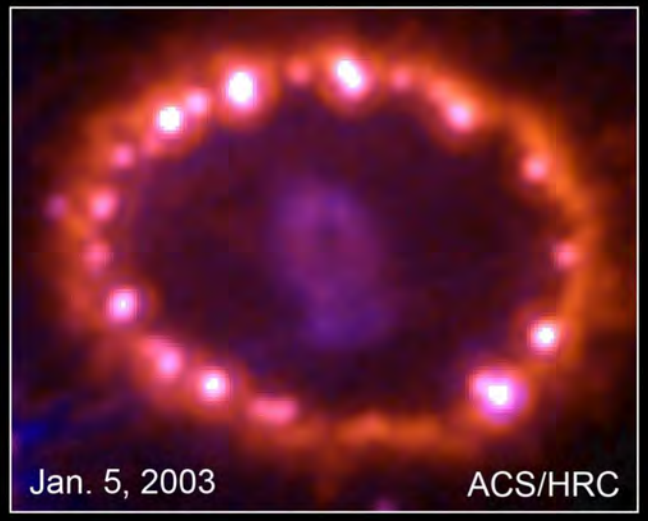
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

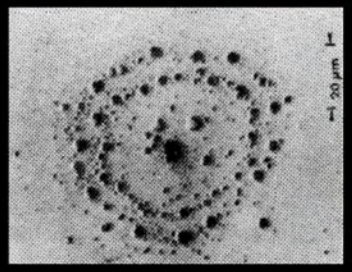
Plasma beams











Top: SN 1987A. Credit: NASA, ESA, P. Challis and R. Kirshner (Harvard-Smithsonian Center for Astrophysics). http://hubblesite.org/newscenter/archive/releases/2007/10

Left: Relativistic electron beam damage produced on polystyrene witness foil. Credit: Winston H. Bostick.

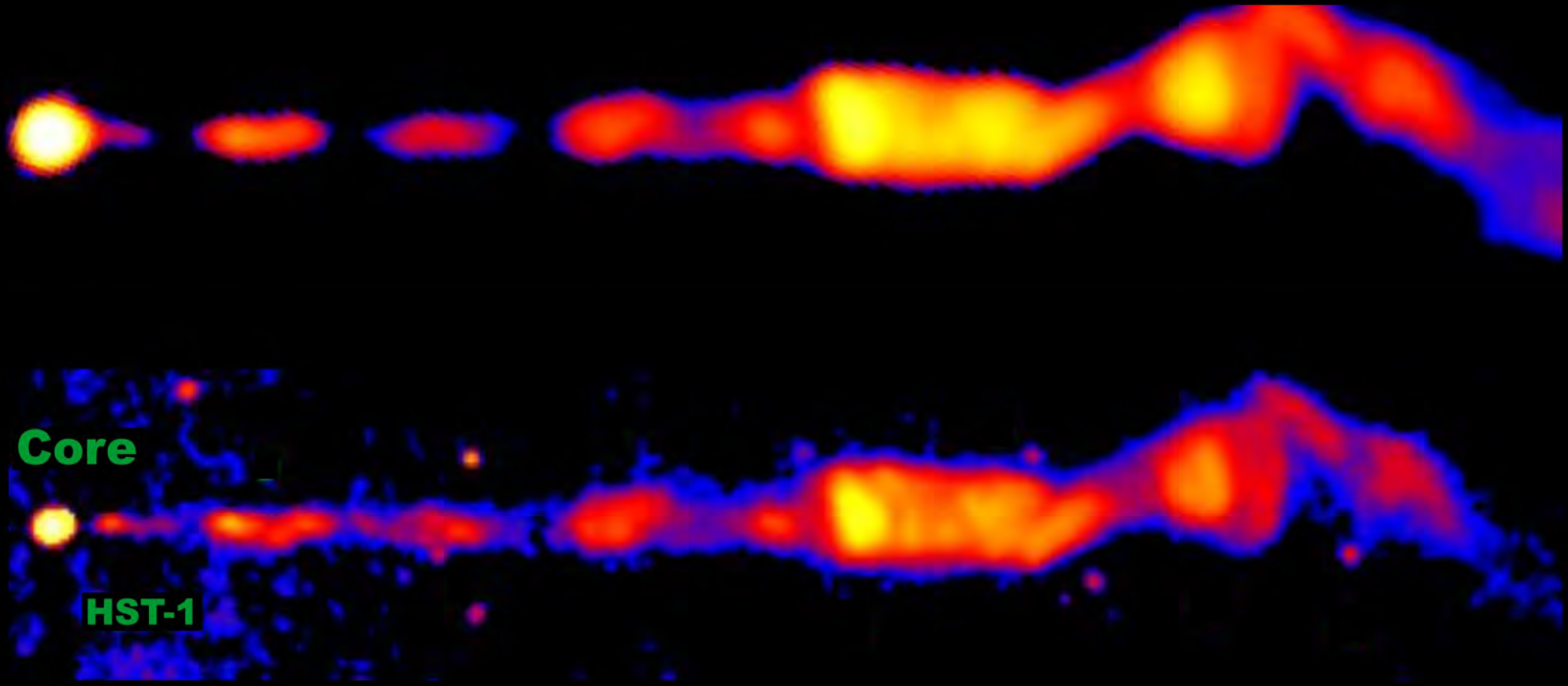
In the laboratory, a **beam** of "solid" charged particles may evolve into a hollow cylinder, the ring further subdividing into individual filamentary currents that may also pair up; see the witness foil (left) about 0.1 mm across.

Designated after the year it was detected, Supernova 1987a has been described as a "ring of pearls". Synchrotron radiation and X-rays have also been observed, that are consistent with a **relativistic particle beam**.

A U G U S T 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
July 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	September 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	30	31	1 1928: Irving Langmuir coins the word "plasma"	2	3
4	5 Holiday (Scotland)	6	7	8	9	10
11	12	13	14	15	16 1957: Irving Langmuir, pioneer dies	17
18	19	20	21	22 1879: William Crookes discovers "radiant matter"	23	24
25	26 Late Summer Bank Holiday	27	28	29	30 1871: Ernest Rutherford born; discovers the proton in 1918	31
1	2	3	4	5	6	7

Plasma jets



M87's jet was first observed by Heber Curtis in 1918 who described it as "a curious straight ray", seen here in both radio (top) and optical wavelengths. Non-thermal polarized synchrotron radiation is also a characteristic.

Jets such as M87 are radio-luminous **pinched plasmas** whose magnetic fields may be derived from an electric current analogous to auroral Birkeland currents in planetary atmospheres. M87's jet is 5400 light years long.

Laboratory jet simulations produce shared characteristics such as power magnitude, isophotal morphology, spectra, and polarized synchrotron radiation as electrons are accelerated though a magnetic field.

Image: M87 jet in radio (top) & optical. Credit: H. L. Marshall/MIT/ NASA/NRAO. **Radio:** NRAO/AUI/ NSF. **Optical:** NASA/STScI/UMBC/E. Perlman *et al.*
http://hea-www.harvard.edu/ XJET/source-d.cgi?M87

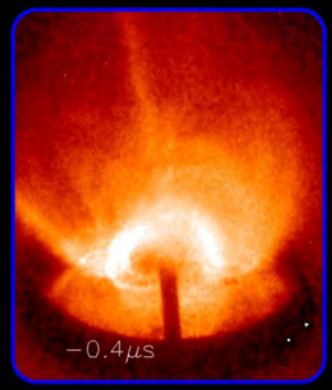
S E P T E M B E R 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 Labor Day	3	4	5 Rosh Hashanah	6	7
8 Grandparent's Day	9	10	11 Patriot Day	12	13	14 Yom Kippur
15	16	17	18	19 Sukkot	20	21
22 20:44 Autumn Equinox	23	24 1870: Georges Claude born. In 1910 he displays the first neon lamp	25	26	27	28 1987: Willard Harrison Bennett, pioneer dies
29	30	1	2	3	4	5
6	7	8	9	10	August 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	October 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Plasma sun

The Sun is a plasma producing the solar wind, as well as solar flares and prominences: arch-shaped, sometimes twisting structures in the corona.

Plasma physicists at Caltech have made a plasma gun which produces arched, erupting, twisted flux tubes (see photo below) that are similar to solar prominences.



Top: Simulated prominences. Credit: J. F. Hansen and P. M. Bellan, Caltech, Bellan Plasma Group, http://ve4xm.caltech.edu/Bellan_plasma_page/

Left: Sun false color X-ray image. Credit: ISAS, Yohkoh Project.

O C T O B E R 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
29	30	1 1956: Winston H. Bostick coins the word "plasmoid"	2	3 1942: Hannes Alfvén predicts Solar plasma waves	4	5
6	7	8	9	10	11	12
13	14 Columbus Day	15	16	17	18	19 1937: Ernest Rutherford dies; discovered the proton
20	21	22	23	24 United Nations Day	25	26
27 British Summer Time Ends 1970: Hannes Alfvén awarded Nobel Prize for his work on magnetohydro-dynamics	28	29	30	31 Halloween Halloween	1	2
3	4	5	6	7		

September

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

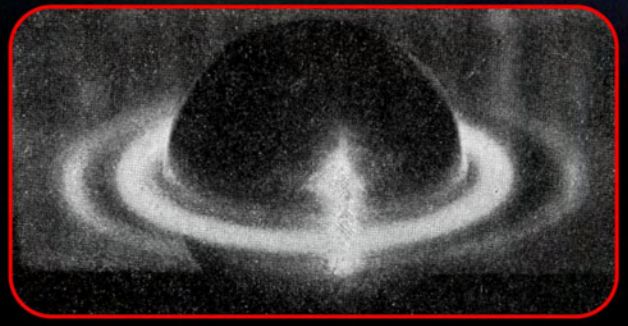
November

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Plasma rings

Top: Cassini's view of Saturn's rings in exaggerated color contrast. **Credit:** NASA/JPL/Space Science Institute. PIA08329. http://photojournal.jpl.nasa.gov/catalog/PIA08329

Right: Kristian Birkeland's small cathode-globe terrella, with about 0.1 milliampere current. Source: Sec.2, Ch VI, *The Norwegian Aurora Polaris Expedition 1902-1903*, publ. 1908.



Backlit by the Sun, Saturn's rings are composed of small particles.

In the interplanetary plasma, dust is charged negatively by electrons, and positively by sunlight, resulting in a "**dusty plasma**". Electromagnetic forces dominate.

During the 1900s, Norwegian scientist Kristian Birkeland experimented wih a magnetized metal globe called a **terrella** in a vacuum chamber (see photo left).

Different currents could produce aurora... and Saturn-like rings.

NOVEMBER 2013

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
October 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	December 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	29	30	31	All Saints Day 1	All Souls Day 2
Daylight Savings Time Ends 3	4	1879: James Clerk Maxwell, pioneer dies Election Day Guy Fawkes Day 5	6	7	8	9
Remembrance Day 10	Veteran's Day 11	12	13	14	15	16
1607: Northern Lights seen over Europe, and described by Johannes Kepler 17	18	19	20	21	22	23
24	25	26	Hanukkah 27	Thanksgiving 28	29	St. Andrew's Day 30
1	2	3	4	5	6	7

Plasma generator

Michael Faraday discovered that an electrically conductive disk rotating in a magnetic field generated an electric current between the central axis and the disk's circumference.

It is sometimes called a Faraday disk, or homopolar generator or **unipolar inductor**.

As electrically conducting plasma rotates through its own magnetic field, electric currents are created along its axes.

Unipolar inductors have been associated with the Sun, stars, galaxies, sunspots, and nebulae (left)... almost everywhere we see a rotating plasma!

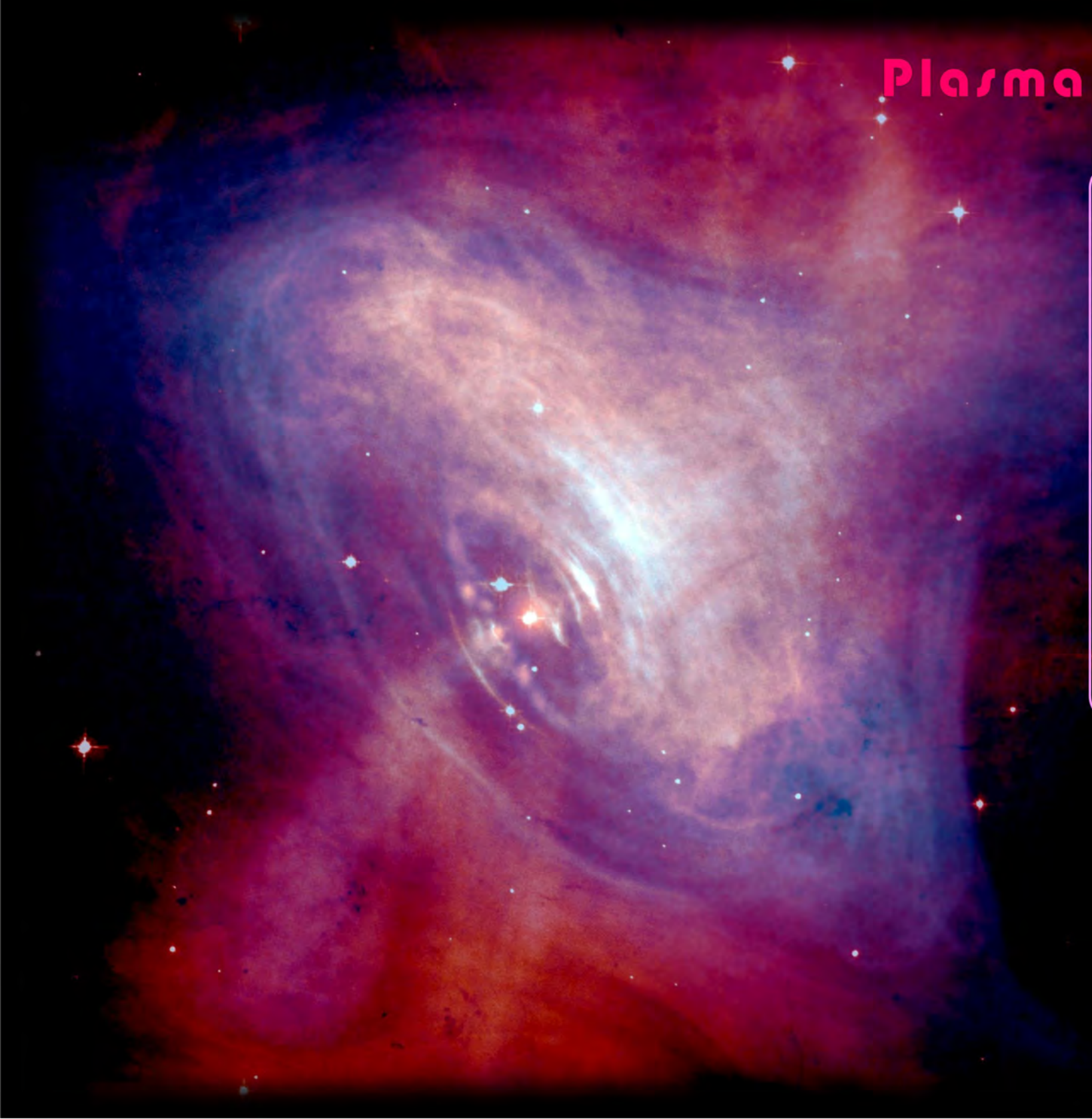


Image: Crab Nebula showing the X-ray (blue), and optical (red) images superimposed. **Credit:** NASA/CXC/ASU/J. Hester et al.

http://hubblesite.org/newscenter/archive/releases/2002/24/image/a/

D E C E M B E R 2 0 1 3

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4 1931: Carl-Gunne Fälthammar, plasma pioneer, born	5	6	7
8	9	10	11 1910: Georges Claude displays the first neon lamp in Paris	12	13 1867: Kristian Birkeland, plasma pioneer born	14
15	16	17	18 1856: Sir J J Thomson, pioneer born	19	20	21 17:11 Winter Solstice Winter Solstice
22	23	24 Christmas Eve	25 Christmas Day Christmas	26 Boxing Day Kwanzaa	27	28
29	30 1979: Charles Bruce, electrical engineer, dies	31	1	2	3	4
5	6	7	8	9		

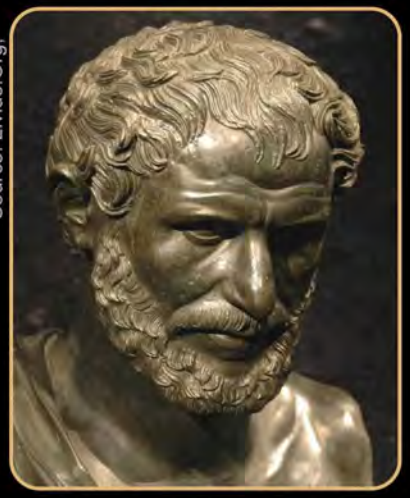
November

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

January

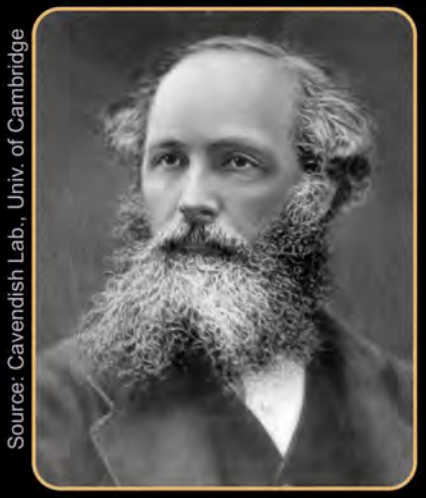
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Plasma Universe pioneers



Source: Livius.Org.

Heraclitus of Ephesus (540–475 BC) noted that: ".. the thunderbolt steers the course of all things"



Source: Cavendish Lab., Univ. of Cambridge

James Clerk Maxwell (1831-1879) devised a unified model of electricity, magnetism and inductance.

Source: *History of Science*, vol. 5, p.106

Sir William Crookes (1832-1919) discovers in 1879 “radiant matter”, he also calls the "Fourth State of Matter”.

Source: *Practical Physics*, Millikan and Gale

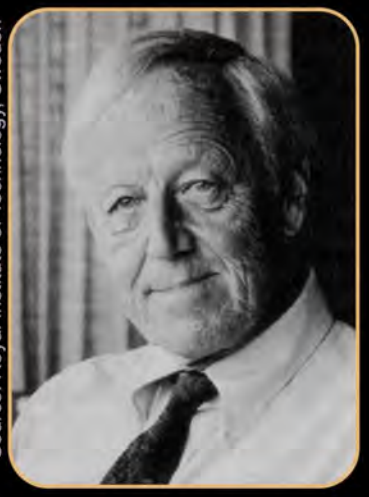
Sir J. J. Thomson (1856-1940) in 1897 identifies “plasma" as consisting of charged particles.

Source: Wikipedia

Kristian Birkeland (1867-1917) models the aurora in a terrella, and predicts “space is filled with electrons and flying electric ions of all kinds”

Source: *GE Review*, Dec. 1932

Irving Langmuir (1881-1957) investigates the properties of ionized gases, and coins the term “plasma”. 1932 Nobel Prize, Chemistry



Source: Royal Institute of Technology, Sweden

Hannes Alfvén (1908-1995) stresses the importance of electrified magnetic space plasmas. Awarded the 1970 Nobel Prize in physics.

2013
Plasma Universe
Calendar

www.plasma-universe.com

With special thanks to Prof. Paul Bellan (California Institute of Technology), Hanna Dahlgren (Royal Institute of Technology, Sweden), Dr. Timothy E. Eastman (www.plasmas.org), Bert Hickman (teslamania.com), Dr. Todd Hoeksema (Stanford University), Dr Herman L. Marshall (Massachusetts Institute of Technology), Dr Anthony L. Peratt (Los Alamos National Laboratory), Caroline Tresman.

Web sites

www.plasma-universe.com • plasmauniverse.info
www.plasmas.org • www.plasmacoalition.org

Books

Cosmic Plasma by Hannes Alfvén, 1981
Physics of the Plasma Universe
by Anthony L. Peratt, 1992
The Electric Sky by Donald E. Scott, 2007

J A N U A R Y 2 0 1 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
29	30	31	1 New Year's Day New Year's Day	2 2nd January (Scotland)	3	4
5	6 The Epiphany	7	8	9	10	11
12	13	14	15	16	17	18
19 1991: Winston H. Bostick, plasma pioneer dies	20 Martin Luther King, Jr. Day	21	22	23	24	25
26	27	28	29	30	31 1881: Irving Langmuir, plasma pioneer born	1
2	3	4	5	6		

December

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	