

Plasma Universe 2014

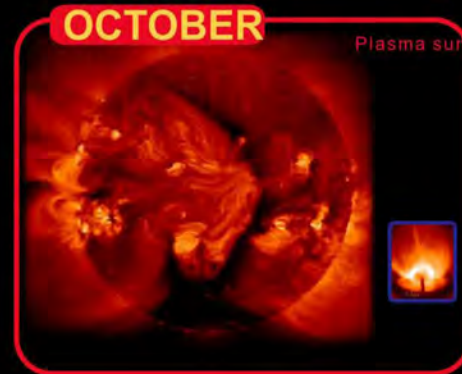
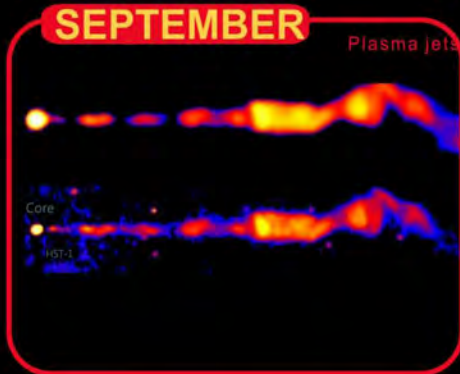
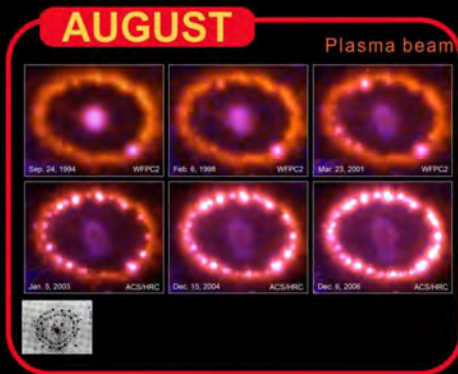
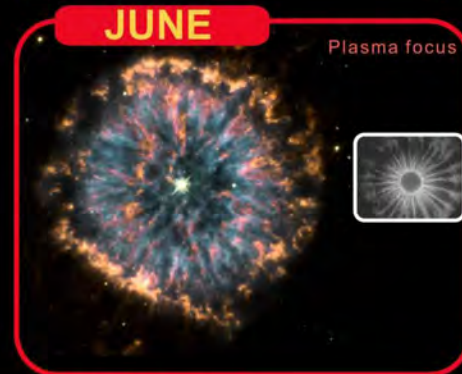
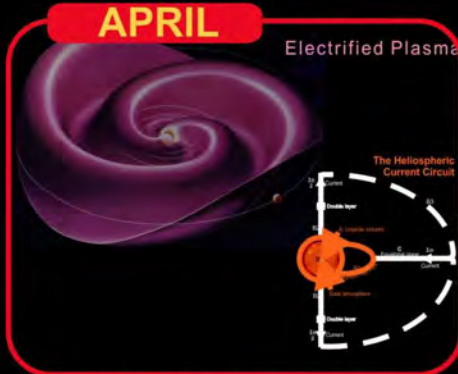
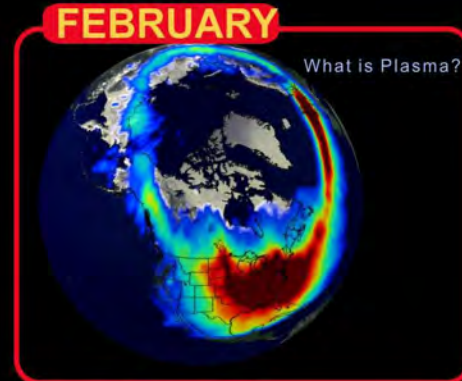
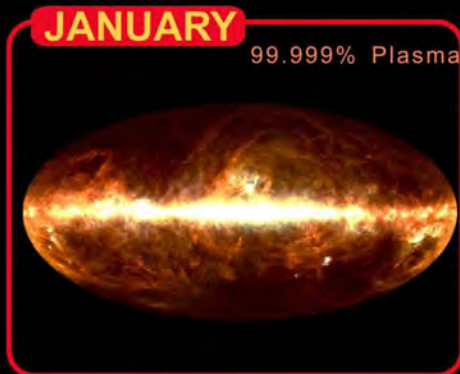
99.999%
of the
visible
Universe

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 (Universit  de Montreal), Gilles Joncas (Universit  Laval), Agnes Acker (Observatoire de Strasbourg), and NASA



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																																																																						
22	23	24	25 Christmas Day	26 Boxing Day	27	28																																																																						
29	30 1979: Charles Bruce, electrical engineer, dies	31	1	2	3	4																																																																						
5	6	7	8	9	<div style="display: flex; justify-content: space-around; font-size: small;"> <div style="text-align: center;"> <p>November</p> <table style="border-collapse: collapse; margin: 0 auto;"> <tr><td></td><td></td><td></td><td></td><td></td><td>1</td><td>2</td></tr> <tr><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr> <tr><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td></tr> <tr><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td></tr> <tr><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr> </table> </div> <div style="text-align: center;"> <p>January</p> <table style="border-collapse: collapse; margin: 0 auto;"> <tr><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr> <tr><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td></tr> <tr><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td></tr> <tr><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td></tr> <tr><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td></td></tr> </table> </div> </div>							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				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	
					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																																																																						
			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																																																																							

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 intergalactic 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**.

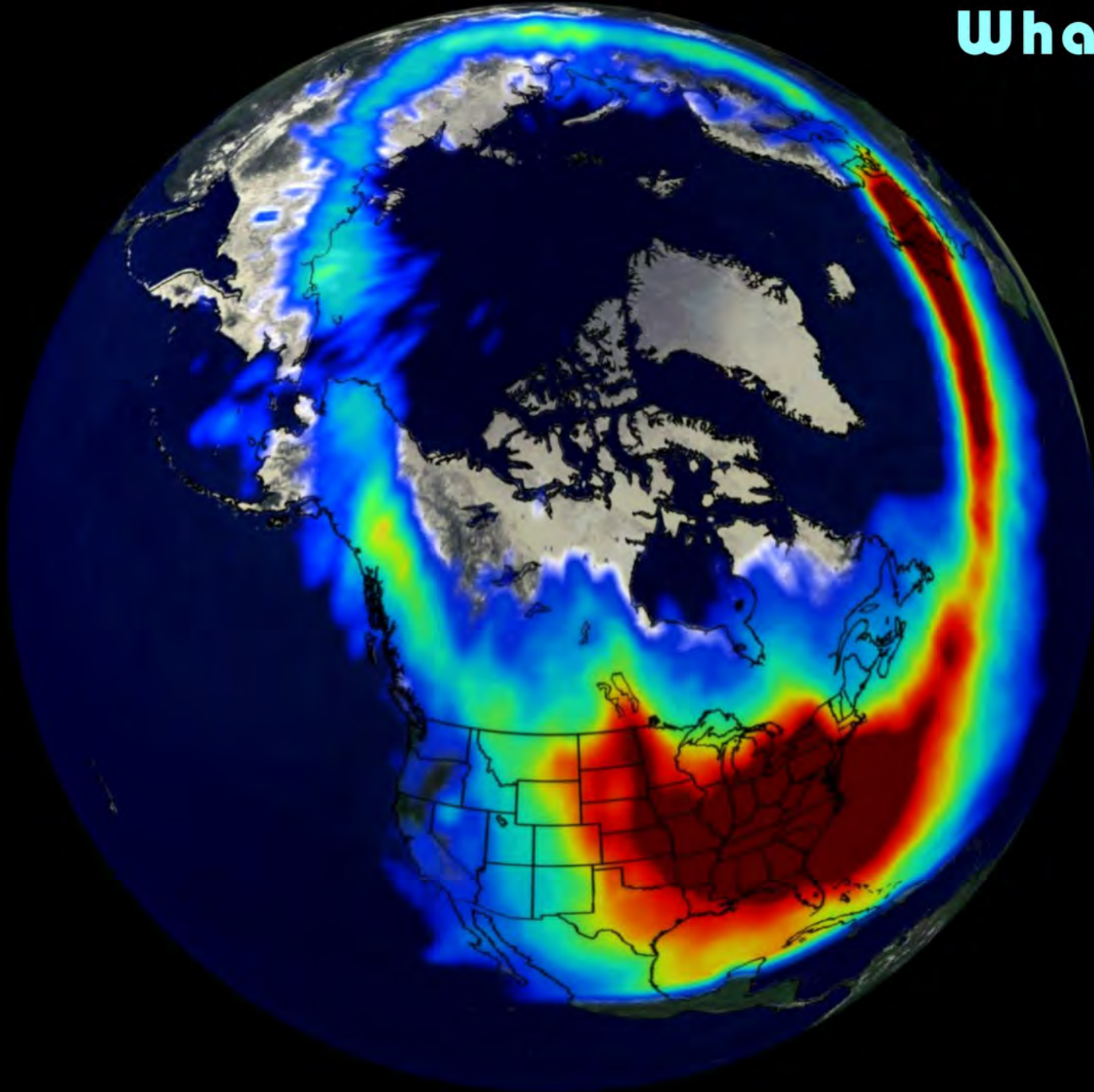
Asteroids, comets and planets, are not made of plasma, but solids, liquids and gases...the exception, not the rule.

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

J A N U A R Y 2 0 1 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																																														
29	30	31	New Year's Day 1	2nd January (Scotland) 2	3	4																																																																																														
5	6	7	8	9	10	11																																																																																														
12	13	14	15	16	17	18																																																																																														
19 1991: Winston H. Bostick, plasma pioneer dies	20	21	22	23	24	25																																																																																														
26	27	28	29	30	31 1881: Irving Langmuir, plasma pioneer born	1																																																																																														
2	3	4	5	6	<table border="1"> <thead> <tr> <th colspan="7">December</th> <th colspan="7">February</th> </tr> </thead> <tbody> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td> </tr> <tr> <td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td> <td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td></td><td></td> </tr> <tr> <td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td> <td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td></td><td></td> </tr> <tr> <td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td> <td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td></td><td></td> </tr> <tr> <td>29</td><td>30</td><td>31</td><td></td><td></td><td></td><td></td> <td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td></td><td></td><td></td> </tr> </tbody> </table>	December							February							1	2	3	4	5	6	7									1	8	9	10	11	12	13	14	2	3	4	5	6	7	8			15	16	17	18	19	20	21	9	10	11	12	13	14	15			22	23	24	25	26	27	28	16	17	18	19	20	21	22			29	30	31					23	24	25	26	27	28				
December							February																																																																																													
1	2	3	4	5	6	7									1																																																																																					
8	9	10	11	12	13	14	2	3	4	5	6	7	8																																																																																							
15	16	17	18	19	20	21	9	10	11	12	13	14	15																																																																																							
22	23	24	25	26	27	28	16	17	18	19	20	21	22																																																																																							
29	30	31					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 4

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

Why is Plasma so?

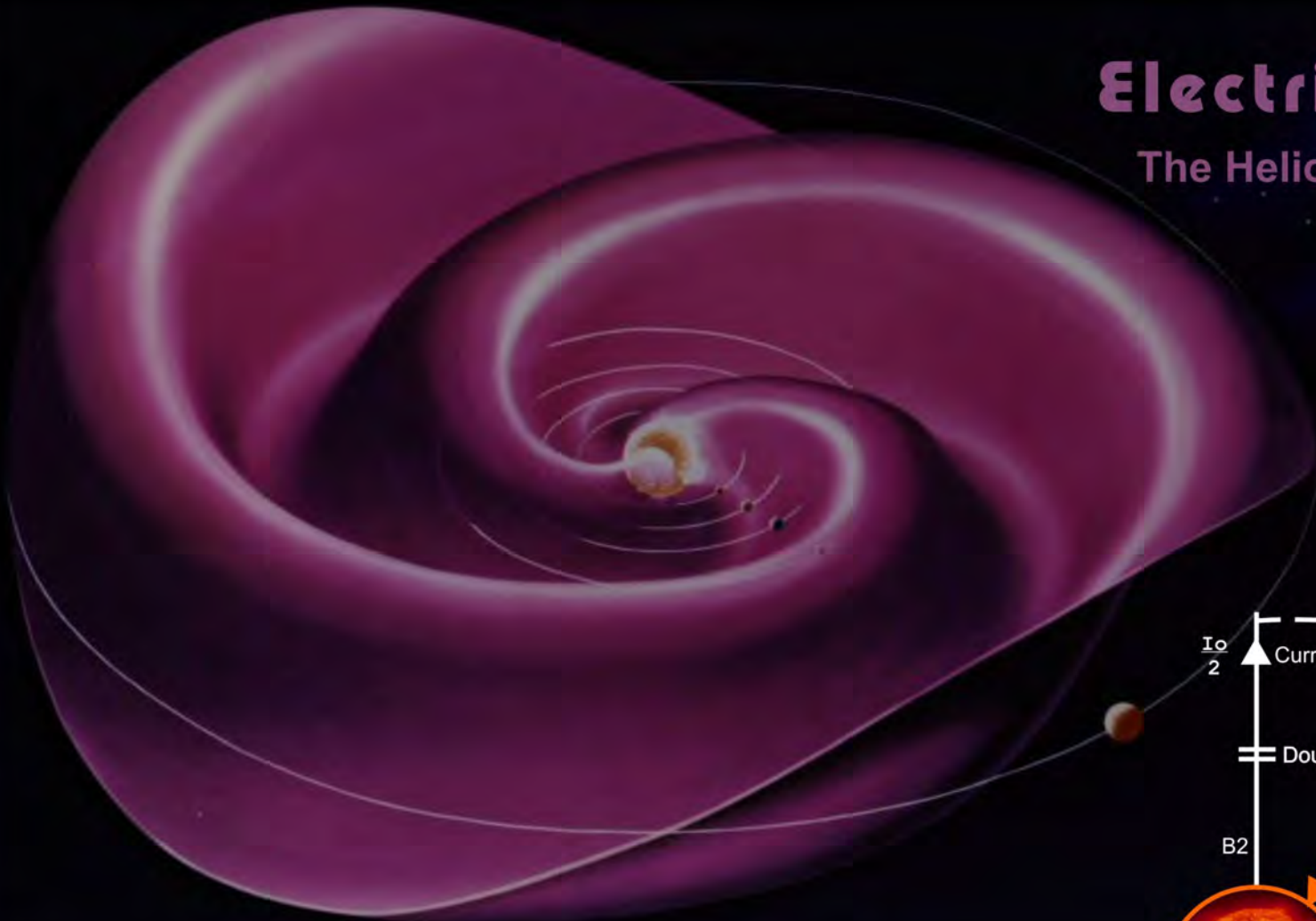
Electro-magnetic forces affect plasmas far more strongly than gravity. For example, solar flares (a plasma) loop, twist and spiral with the Sun's magnetic field, sometimes escaping the Sun's intense gravitational field altogether, and accelerating away as the Solar Wind.

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!

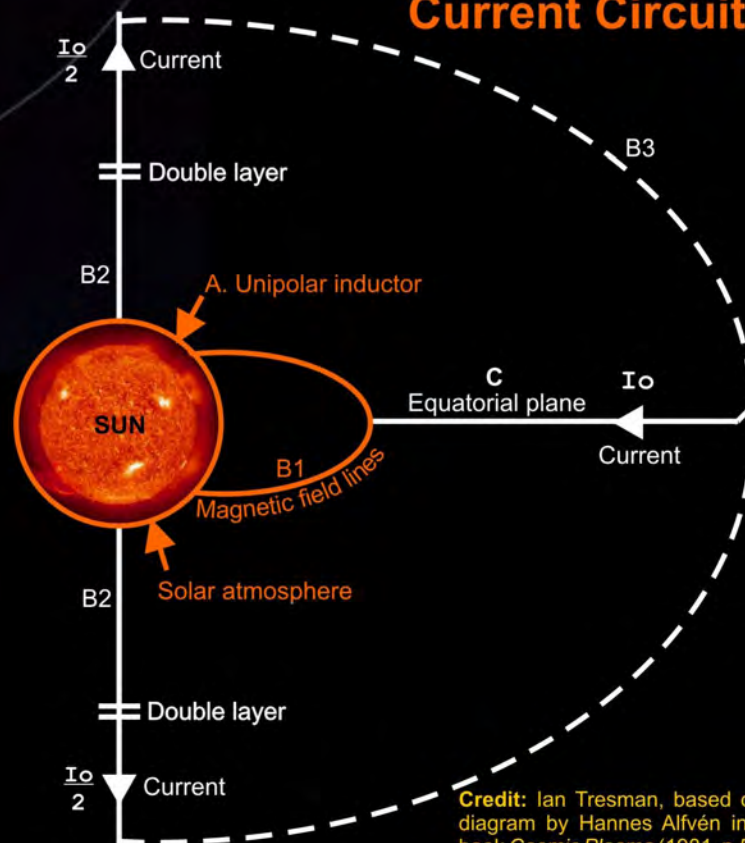
Image: Prediction of Solar Storms in Future, NIX #: MSFC-0201490. Date: 2002-06-01 **Credit:** Steele Hill, Marshall Space Flight Center, NASA
URL: <http://mix.msfc.nasa.gov/abstracts.php?p=2302>

Electrified Plasma

The Heliospheric Current Sheet



The Heliospheric Current Circuit



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).

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/>

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 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	31	April Fool's Day 1	1995: Hannes Alfvén, pioneer dies 2	3	1919: Sir William Crookes, pioneer dies 4	5
6	7	8	9	10	11	12
13	14	Total Lunar Eclipse 7:45 Asia 15	16	17	Good Friday 18	19
20	Queen's Birthday Easter Monday 21	22	St. George's Day 23	24	25	26
27	28	Annular Solar Eclipse 6:04 Australia 29	1897: J.J. Thomson identifies "radiant matter" 30	1	2	3
4	5	6	7	8	<div style="text-align: center;"> March 1 </div> 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	<div style="text-align: center;"> May 1 2 3 </div> 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)

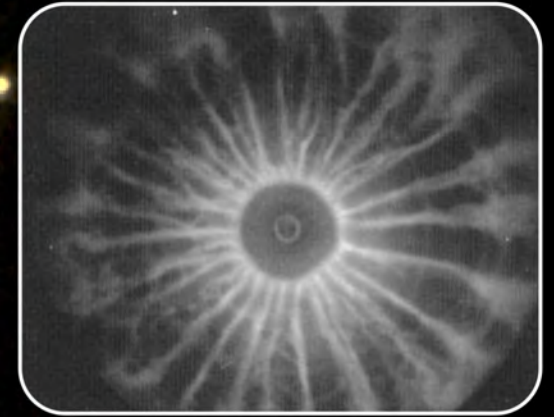
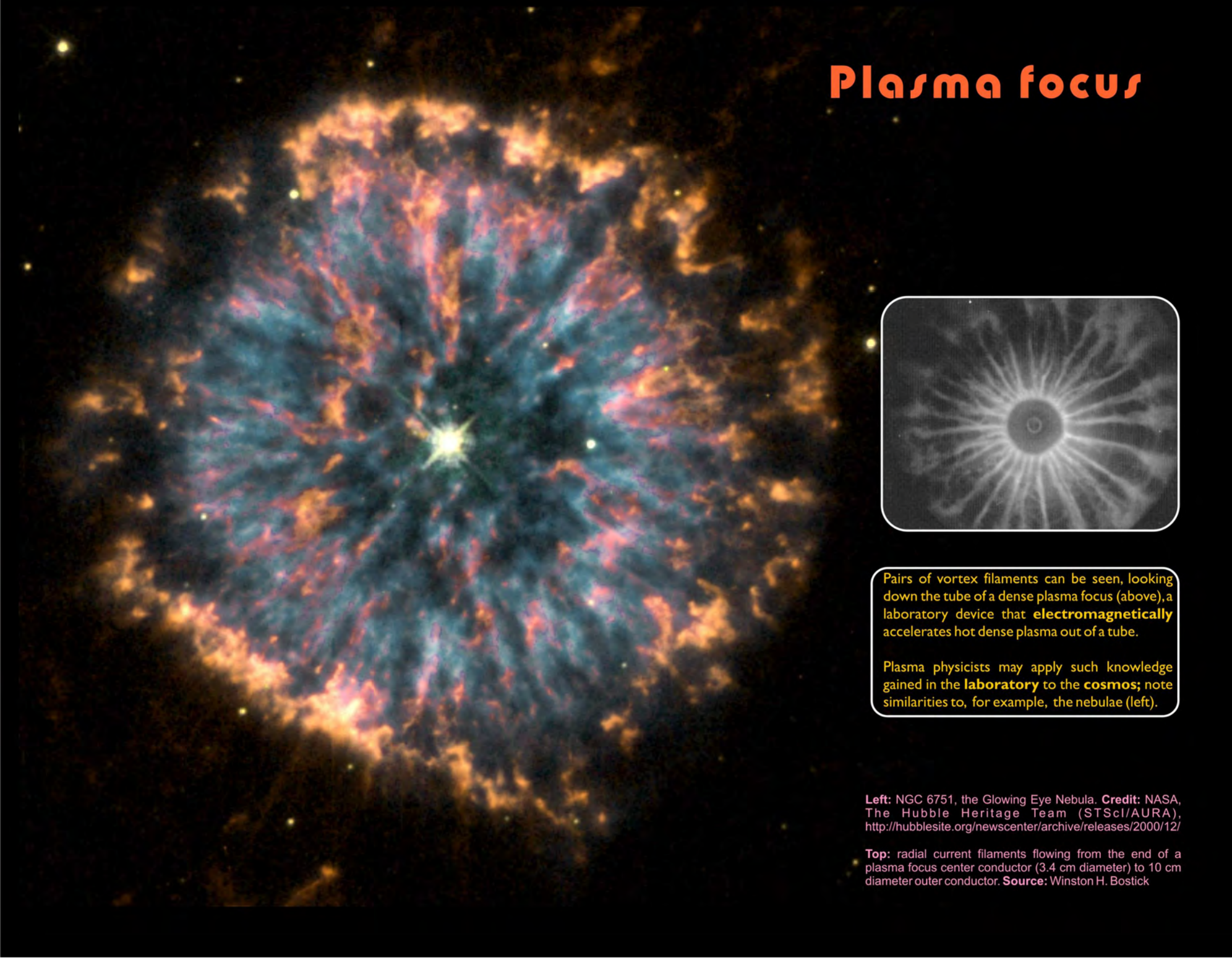
If the magnetic field becomes much stronger along one part of the filament than another, it **pinches** producing a characteristic hour-glass shape. The drinks can (left) was made this way.

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

M A Y 2 0 1 4

Sunday							Monday							Tuesday							Wednesday							Thursday							Friday							Saturday																											
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							29							30							1							2							3																											
1937: Hannes Alfvén predicts intergalactic magnetic field							4							Early May Bank Holiday							5							6							7							8							9							1993: 2nd Plasma Astrophysics and Cosmology Workshop							10						
11							12							13							1937: Hannes Alfvén predicts an interstellar and intergalactic magnetic field							14							15							16							17																				
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							27							28							29							1908: Hannes Alfvén, pioneer born							30							31													
1							Spring Bank Holiday							2							3							4							5							6							7																				

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).

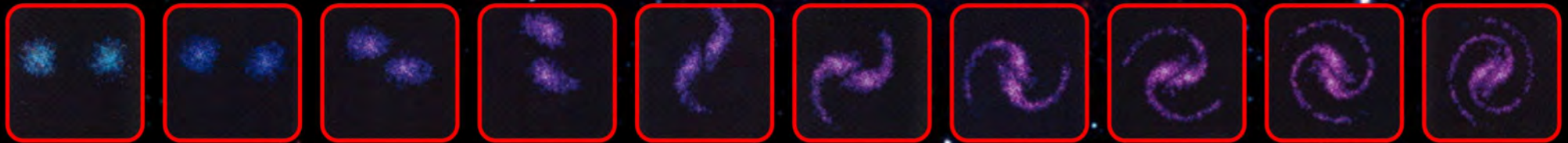
Left: NGC 6751, the Glowing Eye Nebula. **Credit:** NASA, The Hubble Heritage Team (STScI/AURA), <http://hubblesite.org/newscenter/archive/releases/2000/12/>

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 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																																																																																																																																																																								
1	2	3	4	5	6	7																																																																																																																																																																																																																								
8	9	10	11	12	13	14																																																																																																																																																																																																																								
15	16	17	18	19	20	21																																																																																																																																																																																																																								
1917: Kristian Birkeland, pioneer dies Father's Day	1832: Sir William Crookes, pioneer born			1831: James Clerk Maxwell born 1903: Willard Harrison Bennett, plasma pioneer born	Summer Solstice (05:45)																																																																																																																																																																																																																									
22	23	24	25	26	27	28																																																																																																																																																																																																																								
29	30	1	2	3	4	5																																																																																																																																																																																																																								
6	7	8	9	10	<table border="0"> <tr> <td colspan="7"></td> <td colspan="3">May</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td>1</td> <td>2</td> <td>3</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td>11</td> <td>12</td> <td>13</td> <td>14</td> <td>15</td> <td>16</td> <td>17</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td>18</td> <td>19</td> <td>20</td> <td>21</td> <td>22</td> <td>23</td> <td>24</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td>25</td> <td>26</td> <td>27</td> <td>28</td> <td>29</td> <td>30</td> <td>31</td> <td colspan="5"></td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td colspan="5">July</td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td>11</td> <td>12</td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td>13</td> <td>14</td> <td>15</td> <td>16</td> <td>17</td> <td>18</td> <td>19</td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td>20</td> <td>21</td> <td>22</td> <td>23</td> <td>24</td> <td>25</td> <td>26</td> </tr> <tr> <td colspan="7"></td> <td colspan="5"></td> <td>27</td> <td>28</td> <td>29</td> <td>30</td> <td>31</td> <td colspan="2"></td> </tr> </table>									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		
							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																																																																																																																																																																																																														

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).

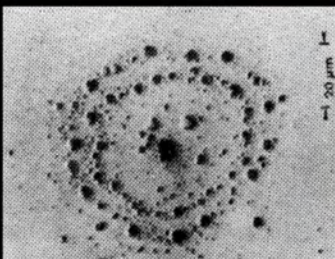
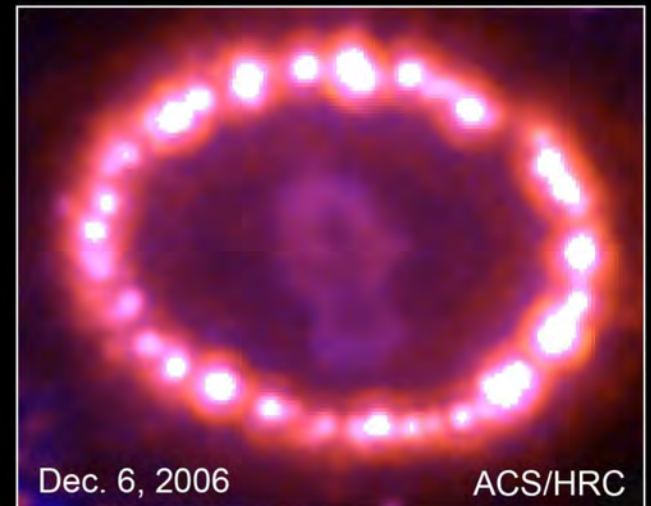
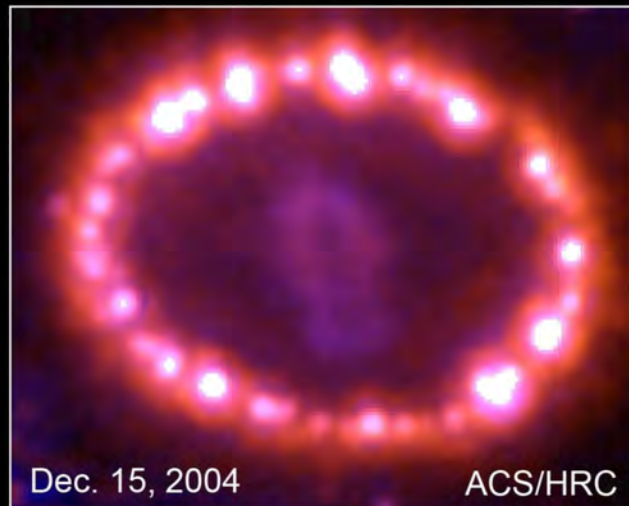
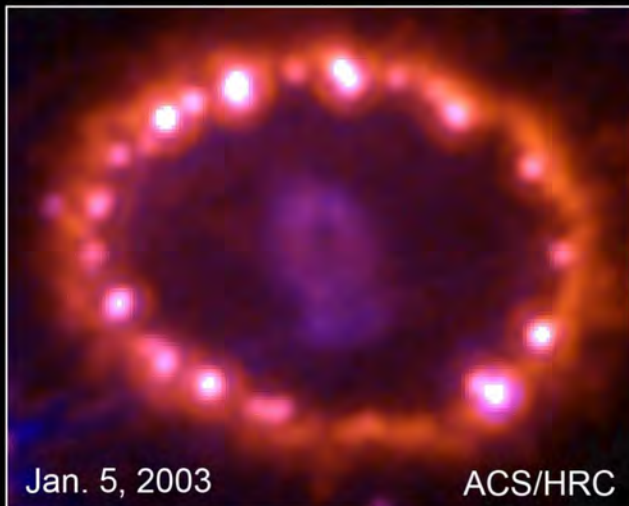
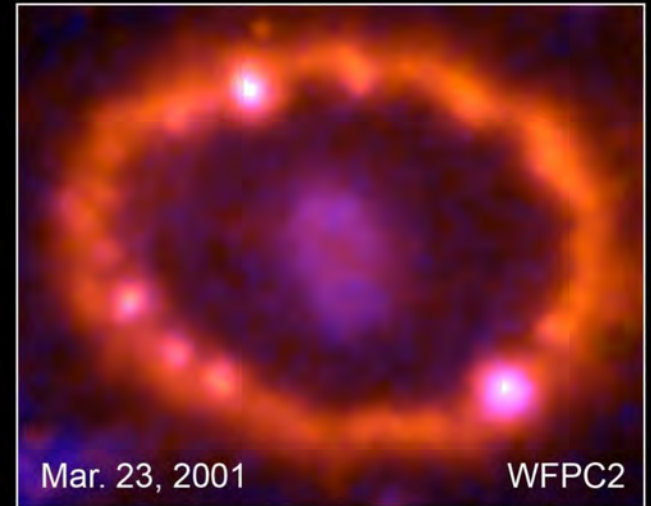
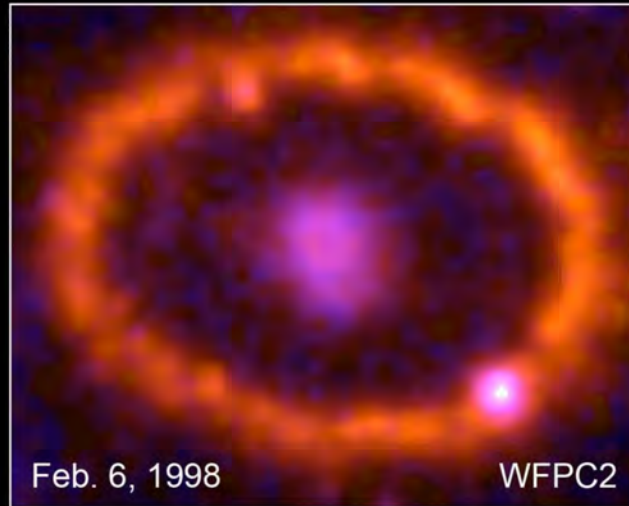
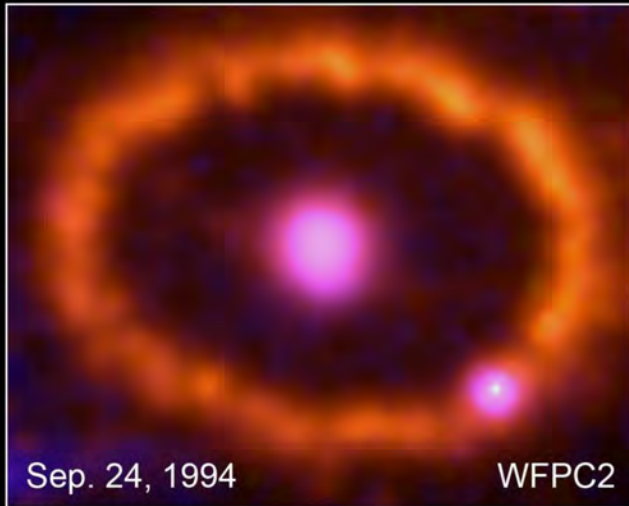
Top: M81 spiral galaxy taken with the Spitzer Space Telescope **Credit:** NASA/JPL-Caltech/S. Willner. <http://www.spitzer.caltech.edu/Media/releases/ssc2003-06/ssc2003-06c.shtml>

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 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																																				
29	30	1 1902: Kristian Birkeland begins 2nd auroral expedition	2	3	4	5 1911: George Johnstone Stoney dies. In 1874 he proposes the existence of the electron																																																																																				
6	7	8	9	10	11	12 Battle of Boyne Day (N. Ireland)																																																																																				
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	<table border="0" style="width: 100%; text-align: center;"> <tr> <td colspan="7">June</td> <td colspan="7">August</td> </tr> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td> <td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td> </tr> <tr> <td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td> <td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td> </tr> <tr> <td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td> <td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td> </tr> <tr> <td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td> <td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> </tr> <tr> <td>29</td><td>30</td><td></td><td></td><td></td><td></td><td></td> <td>31</td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> </table>		June							August							1	2	3	4	5	6	7	3	4	5	6	7	8	9	8	9	10	11	12	13	14	10	11	12	13	14	15	16	15	16	17	18	19	20	21	17	18	19	20	21	22	23	22	23	24	25	26	27	28	24	25	26	27	28	29	30	29	30						31						
June							August																																																																																			
1	2	3	4	5	6	7	3	4	5	6	7	8	9																																																																													
8	9	10	11	12	13	14	10	11	12	13	14	15	16																																																																													
15	16	17	18	19	20	21	17	18	19	20	21	22	23																																																																													
22	23	24	25	26	27	28	24	25	26	27	28	29	30																																																																													
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.

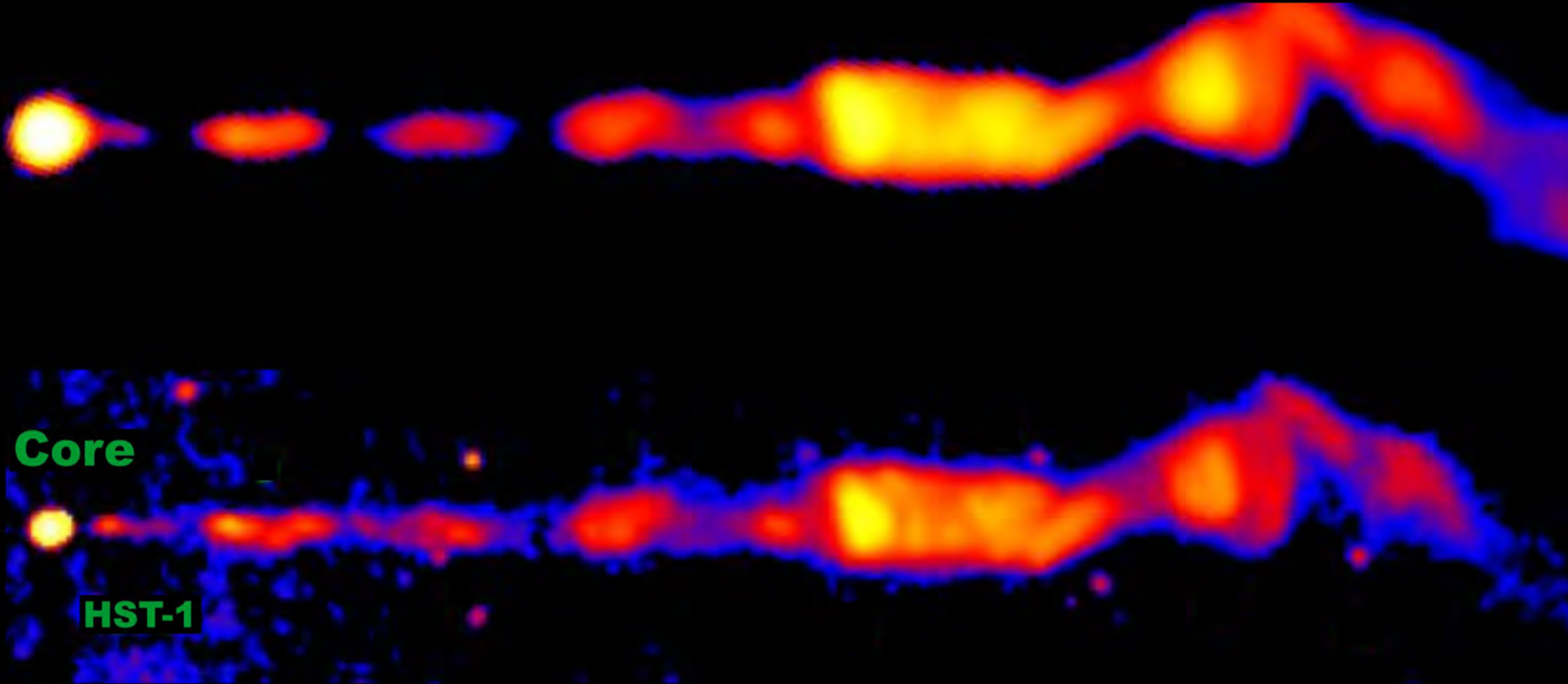
In the laboratory, a **beam** of "solid" charged particles may evolve into a hollow cylinder, the ring further subdividing into individual filamentary currents that may also pair up; see the witness foil (left) about 0.1 mm across.

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 4

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

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 through 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. Perلمان *et al.*, <http://hea-www.harvard.edu/XJET/source-d.cgi?M87>

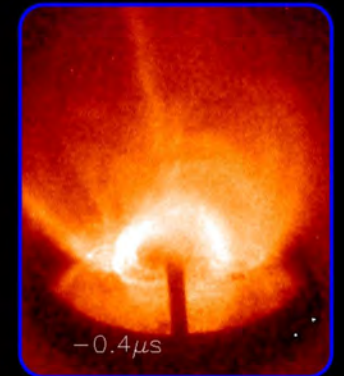
S E P T E M B E R 2 0 1 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																																																																				
31	1	2	3	4	5	6																																																																																																																				
7	8	9	10	11	12	13																																																																																																																				
14	15	16	17	18	19	20																																																																																																																				
21	22	23 1870: Georges Claude born. In 1910 he displays the first neon lamp	24	25	26	27																																																																																																																				
28 1987: Willard Harrison Bennett, pioneer dies	29	30	1	2	3	4																																																																																																																				
5	6	7	8	9	<table border="1"> <thead> <tr> <th colspan="7">August</th> <th colspan="7">October</th> </tr> <tr> <th></th><th></th><th></th><th></th><th></th><th></th><th></th> <th>1</th><th>2</th><th>3</th><th>4</th><th></th><th></th><th></th><th></th><th></th><th></th> </tr> </thead> <tbody> <tr> <td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td> <td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td> </tr> <tr> <td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td> <td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>17</td><td>18</td><td>19</td> </tr> <tr> <td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>24</td><td>25</td><td>26</td> </tr> <tr> <td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> <td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td></td><td></td><td></td><td></td> </tr> <tr> <td></td><td></td><td></td><td></td><td></td><td></td><td>31</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> </tbody> </table>		August							October														1	2	3	4							3	4	5	6	7	8	9	5	6	7	8	9	10	11	12	13	14	10	11	12	13	14	15	16	12	13	14	15	16	17	18	17	18	19	17	18	19	20	21	22	23	19	20	21	22	23	24	25	24	25	26	24	25	26	27	28	29	30	26	27	28	29	30	31											31										
August							October																																																																																																																			
							1	2	3	4																																																																																																																
3	4	5	6	7	8	9	5	6	7	8	9	10	11	12	13	14																																																																																																										
10	11	12	13	14	15	16	12	13	14	15	16	17	18	17	18	19																																																																																																										
17	18	19	20	21	22	23	19	20	21	22	23	24	25	24	25	26																																																																																																										
24	25	26	27	28	29	30	26	27	28	29	30	31																																																																																																														
						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.



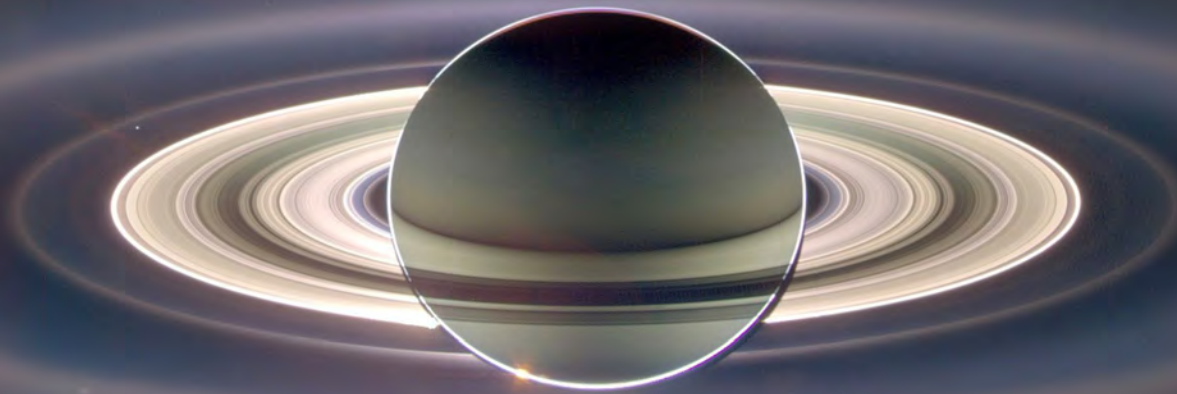
Top: Simulated prominences. Credit: J. F. Hansen and P. M. Bellan, Caltech, Bellan Plasma Group, http://ve4xm.caltech.edu/Bellan_plasma_page/

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

O C T O B E R 2 0 1 4

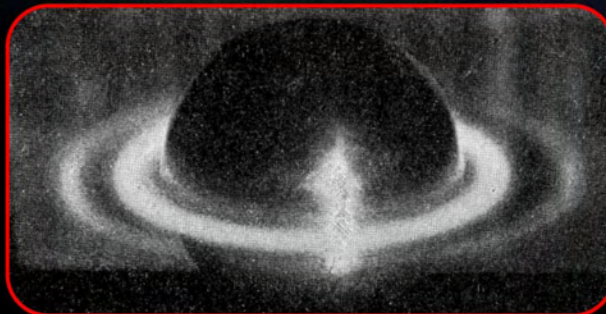
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																								
28	29	30	1 1956: Winston H. Bostick coins the word "plasmoid"	2	3 1942: Hannes Alfvén predicts Solar plasma waves	4																																																																								
5	6	7	8	9	10	11																																																																								
12	13	14	15	16	17	18																																																																								
19 1937: Ernest Rutherford dies; discovered the proton	20	21	22	23	24	25																																																																								
26 British Summer Time Ends	27 1970: Hannes Alfvén awarded Nobel Prize for his work on magnetohydrodynamics	28	29	30	31 Halloween	1																																																																								
2	3	4	5	6	<table border="0"> <tr> <td colspan="6">September</td> <td colspan="6">November</td> </tr> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> </tr> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td> </tr> <tr> <td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td> <td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td> </tr> <tr> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> </tr> <tr> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> </tr> </table>		September						November						1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	10	11	12	7	8	9	10	11	12	13	14	15	16	17	18	13	14	15	16	17	18	19	20	21	22	23	24	19	20	21	22	23	24	25	26	27	28	29	30	25	26	27	28	29	30
September						November																																																																								
1	2	3	4	5	6	1	2	3	4	5	6																																																																			
7	8	9	10	11	12	7	8	9	10	11	12																																																																			
13	14	15	16	17	18	13	14	15	16	17	18																																																																			
19	20	21	22	23	24	19	20	21	22	23	24																																																																			
25	26	27	28	29	30	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 with a magnetized metal globe called a **terrella** in a vacuum chamber (see photo left).

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

N O V E M B E R 2 0 1 4

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

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.

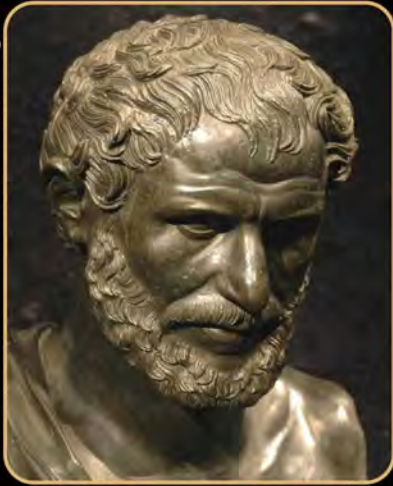
<http://hubblesite.org/newscenter/archive/releases/2002/24/image/a/>

D E C E M B E R 2 0 1 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday																																																																																			
30	1	2	3	1931: Carl-Gunne Fälthammar, plasma pioneer, born	4	5																																																																																			
7	8	9	10	1910: Georges Claude displays the first neon lamp in Paris	11	12																																																																																			
14	15	16	17	1856: Sir J J Thomson, pioneer born	18	19																																																																																			
21	22	23	24	Christmas Day	25	26																																																																																			
28	29	30	31	1979: Charles Bruce, electrical engineer, dies	1	2																																																																																			
4	5	6	7	8	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p style="text-align: center; margin: 0;">November</p> <table style="font-size: small; border-collapse: collapse; margin: 0 auto;"> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td></tr> <tr><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td></td></tr> <tr><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td></td></tr> <tr><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td></td></tr> <tr><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td></td></tr> <tr><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table> </div> <div style="width: 45%;"> <p style="text-align: center; margin: 0;">January</p> <table style="font-size: small; border-collapse: collapse; margin: 0 auto;"> <tr><td></td><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td></tr> <tr><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr> <tr><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr> <tr><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr> <tr><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td></tr> </table> </div> </div>									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												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
							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																																																																																									
				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



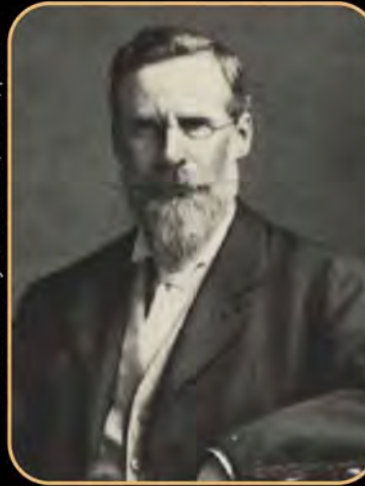
Heraclitus of Ephesus (540–475 BC) noted that: “.. the thunderbolt steers the course of all things”

Source: Cavendish Lab., Univ. of Cambridge



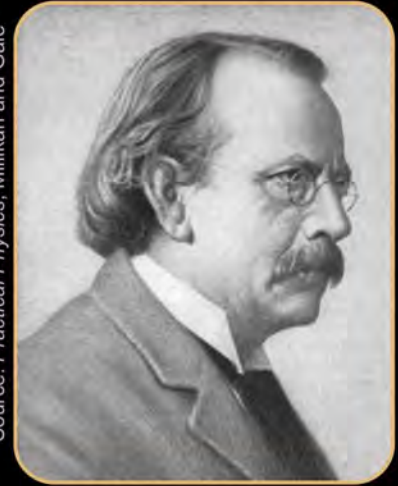
James Clerk Maxwell (1831-1879) devised a unified model of electricity, magnetism and inductance.

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.

2014
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

Text & compilation © 2013 Ian Tresman

J A N U A R Y 2 0 1 5

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