

Plasma Universe 2011

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

COVER

Plasma Universe 2010

99.999% of the Universe

Plasma Universe 2004

www.plasma-universe.com

JANUARY

99.999% Plasma

FEBRUARY

What is Plasma?

MARCH

Why is Plasma so?

APRIL

Electrified Plasma

The Heliospheric Current Circuit

MAY

Pinched Plasma filaments

JUNE

Plasma focus ?

JULY

Plasma galaxy

[] [] [] [] [] [] [] [] [] []

AUGUST

Plasma beams

| | | |
|-------------------------|--------------------------|-------------------------|
| Sep. 24, 1994 WFPC2 | Feb. 6, 1998 WFPC2 | Mar. 23, 2001 WFPC2 |
| Jan. 5, 2003 ACS/HRC | Dec. 15, 2004 ACS/HRC | Dec. 6, 2006 ACS/HRC |

SEPTEMBER

Plasma jets

Core
Sheath

OCTOBER

Plasma run

NOVEMBER

Plasma ring

DECEMBER

Plasma generator

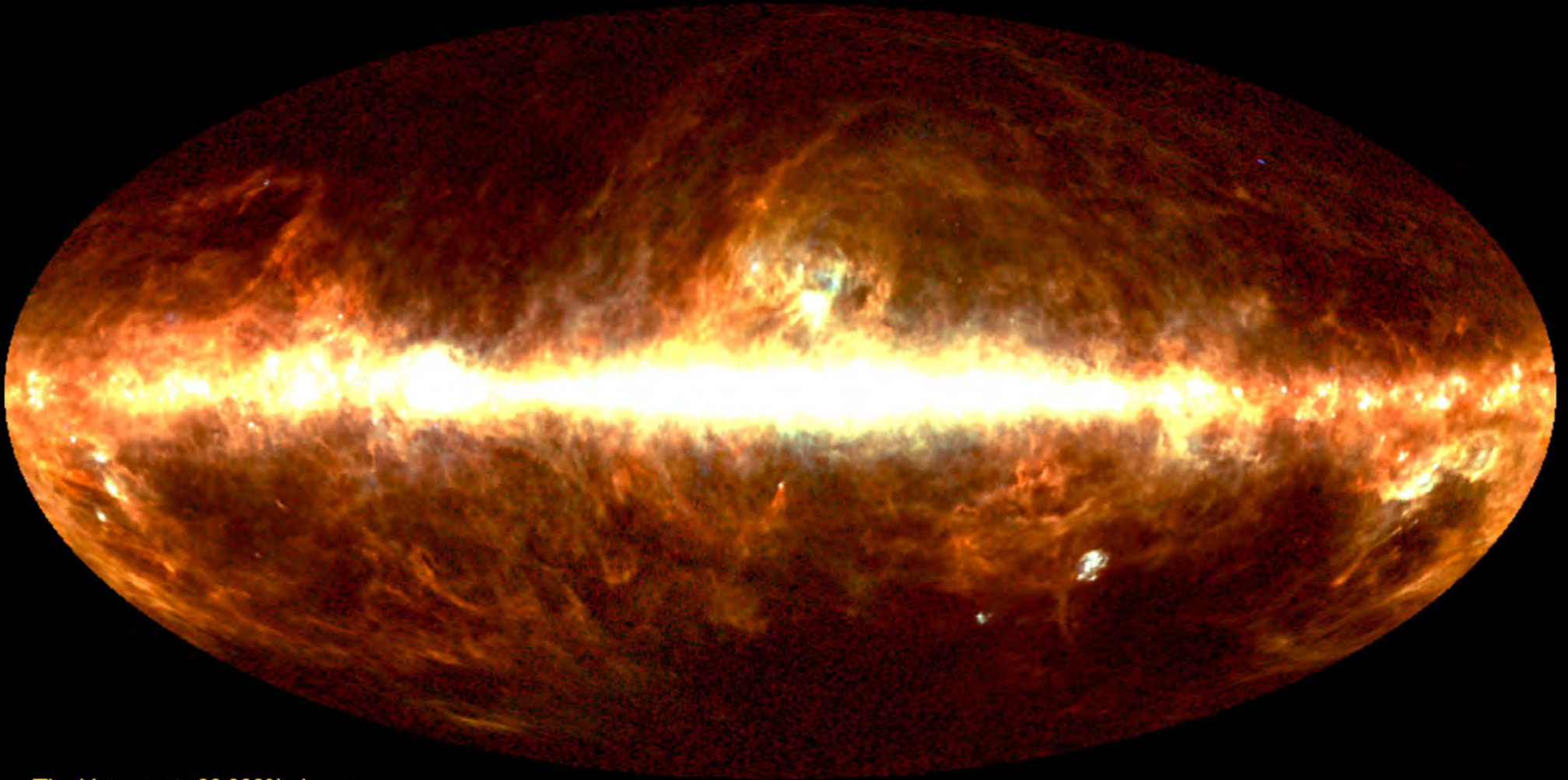
Plasma Universe pioneers

www.plasma-universe.com

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

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 29 | 30 | 1 Hanukkah | 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 Geminids Meteor Shower | 15 | 16 | 17 | 18 1856: Sir J J Thomson, pioneer born | 19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 21 08:16 UT: Total lunar eclipse Winter Solstice FULL MOON | 22 | 23 | 24 Christmas Eve | 25 Christmas Day Christmas | 26 Boxing Day Kwanzaa | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 Bank Holiday | 28 Bank Holiday | 29 | 30 1979: Charles Bruce, electrical engineer, dies | 31 | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | 4 | 5 | 6 | 7 | <table style="width: 100%; font-size: small; text-align: left;"> <tr> <td colspan="7" style="text-align: center;">November</td> <td colspan="7" style="text-align: center;">January</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> | | November | | | | | | | January | | | | | | | 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 | | | | | | |
| November | | | | | | | January | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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**.

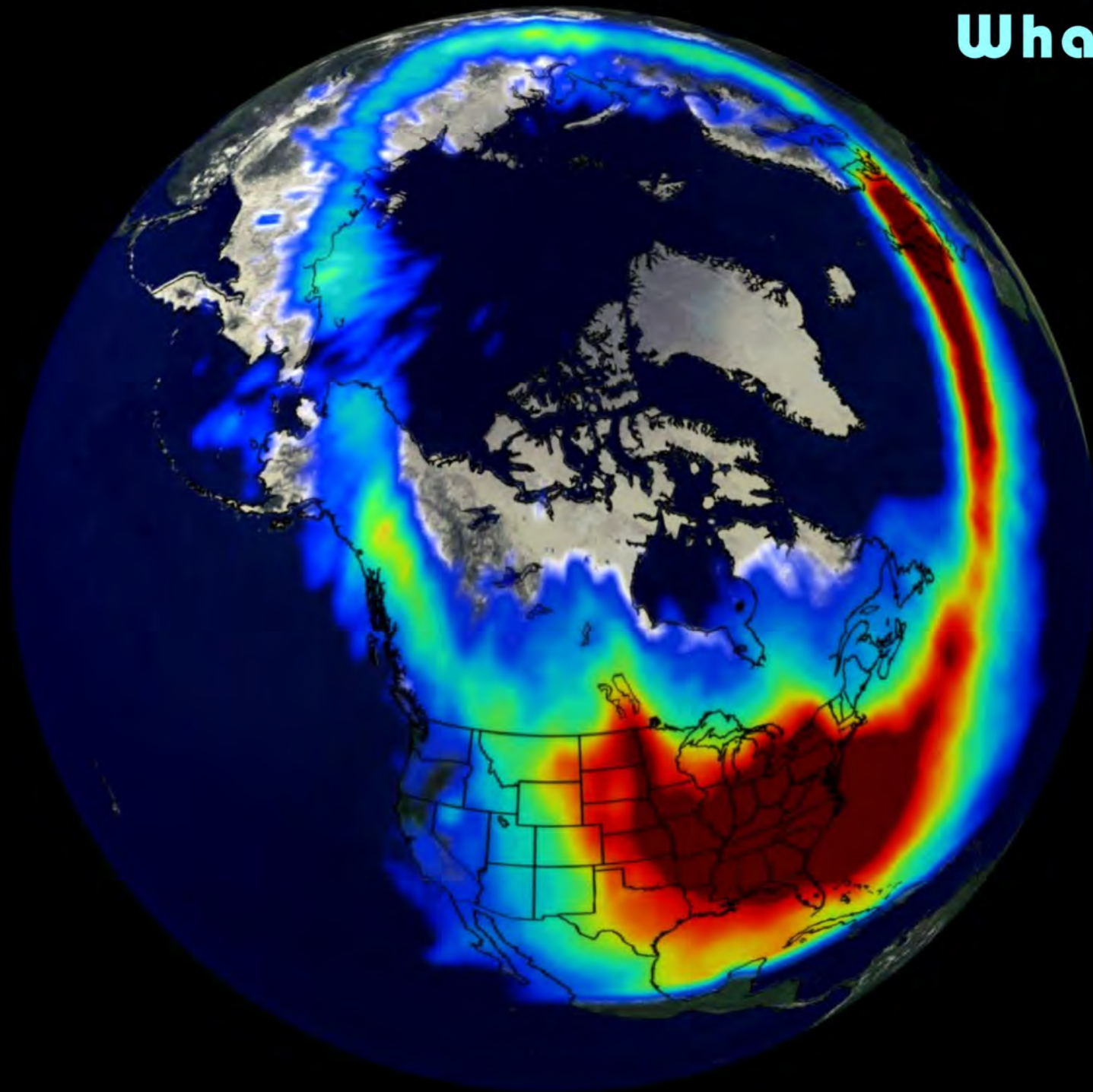
Asteroids, comets and planets, are not made of plasma, but solids, liquids and gases... the exception, not the rule.

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

J A N U A R Y 2 0 1 1

| Monday | | | | | Tuesday | | | | | | Wednesday | | | Thursday | | | Friday | | Saturday | | Sunday | | | |
|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--------------|--|--|--------|--|----------------------------------|--|--------------------------------|--|----|--|
| 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 | | | | | | 29 | | | 30 | | | 31 | | New Year's Day New Year's Day | | 1 2nd January (Scotland) | | 2 | |
| | | | | | 08:50 UT: Partial Solar eclipse, N. Europe | | | | | | | | | The Epiphany | | | | | | | | | | |
| 3 | | | | | 4 | | | | | | 5 | | | 6 | | | 7 | | 8 | | 9 | | | |
| 10 | | | | | 11 | | | | | | 12 | | | 13 | | | 14 | | 15 | | 16 | | | |
| Martin Luther King, Jr. Day | | | | | 17 | | | | | | 1991: Winston H. Bostick, plasma pioneer dies | | | 19 | | | 20 | | 21 | | 22 | | 23 | |
| 24 | | | | | 25 | | | | | | 26 | | | 27 | | | 28 | | 29 | | 30 | | | |
| 1881: Irving Langmuir, plasma pioneer born | | | | | 31 | | | | | | 2 | | | 3 | | | 4 | | 5 | | 6 | | | |

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.

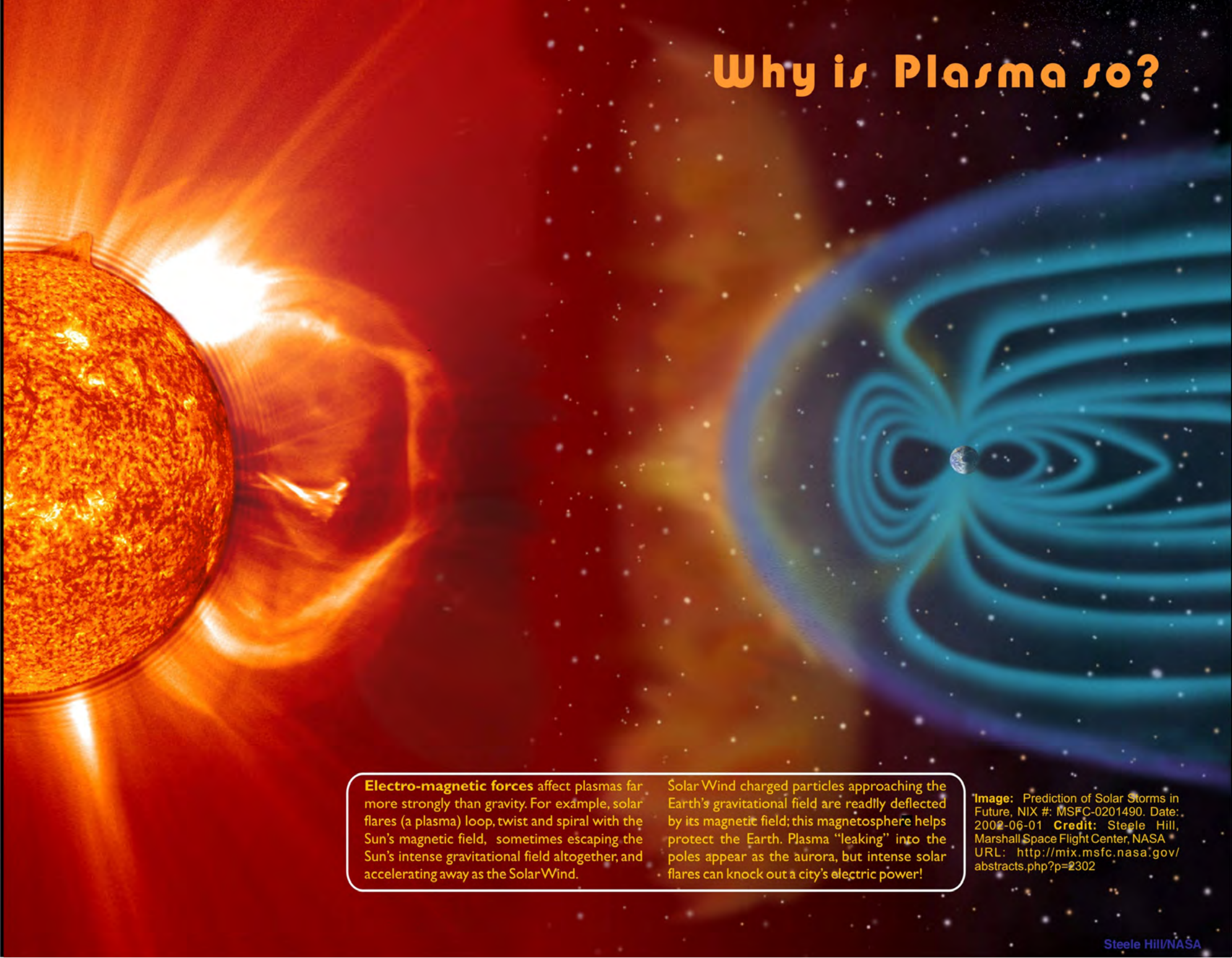
Plasma is a mixture of free-moving negatively charged electrons and positive ions (that make up atoms and molecules in other forms of matter). Plasma may also contain neutral atoms, molecules and dust, such as the Earth's ionosphere, in which we see the aurora.

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 1

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 31 | 1 | Groundhog Day 1897: Kristian Birkeland starts 1st (failed) expedition | 2 | 1925: Oliver Heaviside dies. He reformulated Maxwell's equations Chinese New Year (Year of the Rabbit) | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 8 | 9 | 10 | 11 | Lincoln's Birthday | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Valentine's Day Valentine's Day | 14 | 1826: George Stoney is born; proposed existence of the electron | 15 | 16 | 17 | 18 | 19 | 1989: First Workshop on Plasma Cosmology, USA | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Washington's Birthday President's Day | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 8 | 9 | 10 | 11 | <div style="display: flex; justify-content: space-around; font-size: small;"> <div style="text-align: center;"> <p>January</p> <table border="1" style="border-collapse: collapse; font-size: x-small;"> <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> <tr><td>31</td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table> </div> <div style="text-align: center;"> <p>March</p> <table border="1" style="border-collapse: collapse; font-size: x-small;"> <tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td></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>13</td></tr> <tr><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td></tr> <tr><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td></tr> <tr><td>28</td><td>29</td><td>30</td><td>31</td><td></td><td></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 | 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 | 31 | | | |
| | | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 10 | 11 | 12 | 13 | 14 | 15 | 16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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!

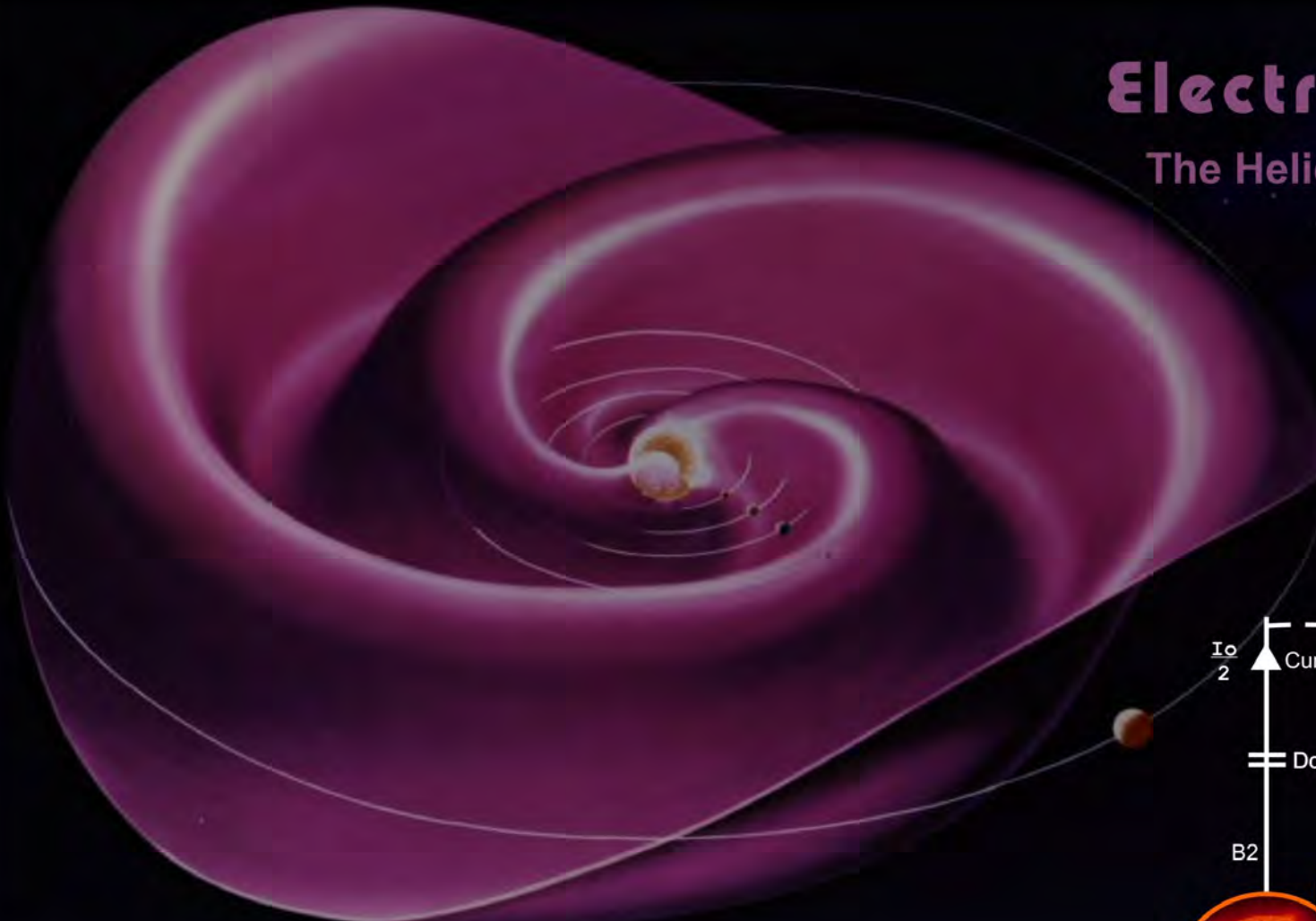
Image: Prediction of Solar Storms in Future, NIX #: MSFC-0201490. Date: 2002-06-01 **Credit:** Steele Hill, Marshall Space Flight Center, NASA
URL: <http://mix.msfc.nasa.gov/abstracts.php?p=2302>

M A R C H 2 0 1 1

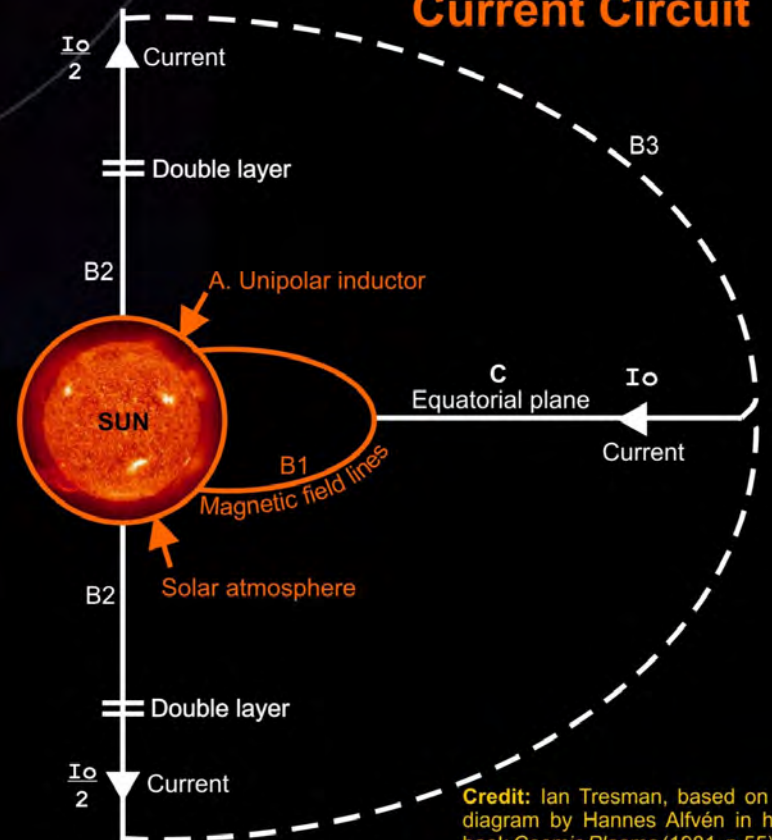
| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 28 | St. David's Day 1 | 2 | 3 | 4 | 1916: Winston H. Bostick, pioneer born 5 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 8 | Ash Wednesday Ash Wednesday 9 | 10 | 11 | 12 | Daylight Savings Time Begins 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | 15 | 16 | St. Patrick's Day St. Patrick's Day (N. Ireland) 17 | 18 | 19 | Spring Equinox Purim 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | 22 | 23 | 24 | 25 | 26 | British Summertime Begins 27 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | 29 | 30 | 31 | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 5 | 6 | 7 | 8 | <table border="0"> <tr> <td colspan="6">February</td> <td colspan="6">April</td> </tr> <tr> <td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> <td></td><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td> </tr> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td> <td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td> </tr> <tr> <td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td> <td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td> </tr> <tr> <td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td> <td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> </tr> <tr> <td>28</td><td></td><td></td><td></td><td></td><td></td><td></td> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td></td> </tr> </table> | | February | | | | | | April | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | | | | 1 | 2 | 3 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 28 | | | | | | | 25 | 26 | 27 | 28 | 29 | 30 | |
| February | | | | | | April | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | 25 | 26 | 27 | 28 | 29 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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 1

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 28 | 29 | 30 | 31 | 1 April Fool's Day April Fool's Day | 2 1995: Hannes Alfvén, pioneer dies | 3 Mother's Day | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 1919: Sir William Crookes, pioneer dies | 5 | 6 | 7 | 8 | 9 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | 12 | 13 | 14 | 15 Tax Day | 16 | 17 Palm Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 Passover | 19 | 20 | 21 Queen's Birthday | 22 Earth Day Good Friday Good Friday | 23 St. George's Day | 24 Easter Easter Palm Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 Easter Monday | 26 | 27 | 28 | 29 | 30 1897: J.J. Thomson identifies "radiant matter" | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 3 | 4 | 5 | 6 | <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>March</p> <table border="1"> <tr><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>13</td></tr> <tr><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td></tr> <tr><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td></tr> <tr><td>28</td><td>29</td><td>30</td><td>31</td><td></td><td></td><td></td></tr> </table> </div> <div style="text-align: center;"> <p>May</p> <table border="1"> <tr><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></tr> <tr><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr> <tr><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td></tr> <tr><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td></tr> <tr><td>30</td><td>31</td><td></td><td></td><td></td><td></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 | 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 | 31 | | | | | |
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| 14 | 15 | 16 | 17 | 18 | 19 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 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)

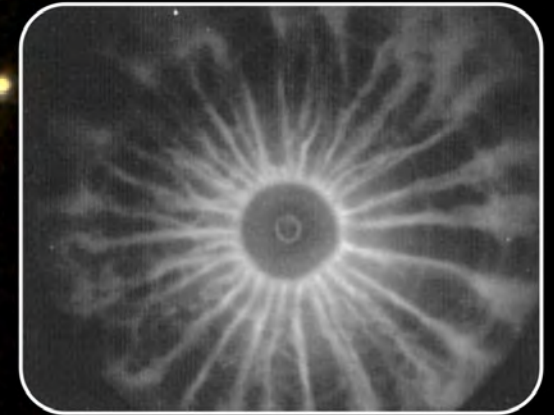
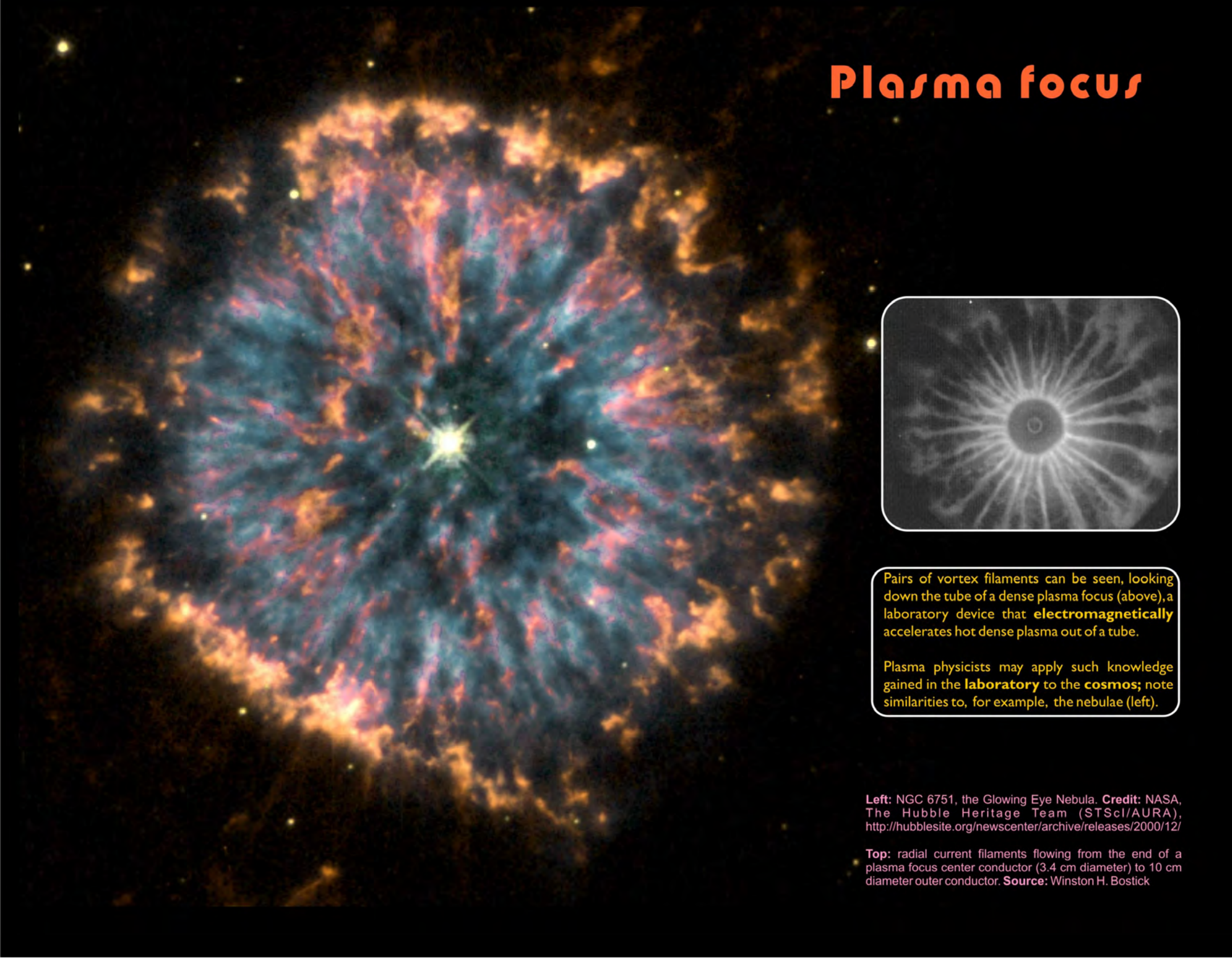
If the magnetic field becomes much stronger along one part of the filament than another, it **pinches** producing a characteristic hour-glass shape. The drinks can (left) was made this way.

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

M A Y 2 0 1 1

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

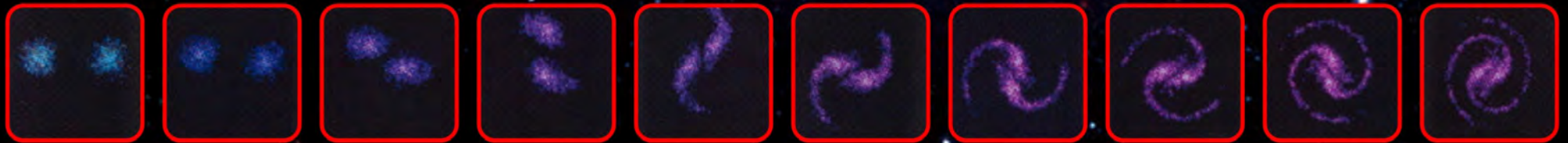
Left: NGC 6751, the Glowing Eye Nebula. **Credit:** NASA, The Hubble Heritage Team (STScI/AURA), <http://hubblesite.org/newscenter/archive/releases/2000/12/>

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 1

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

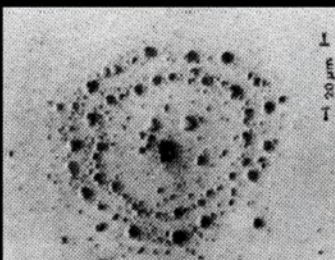
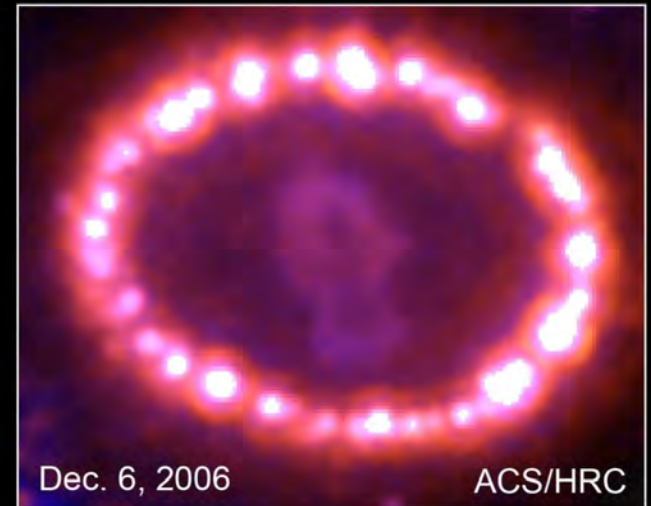
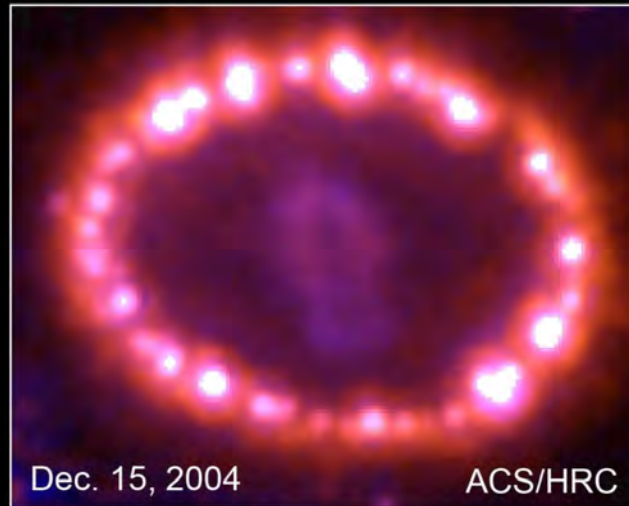
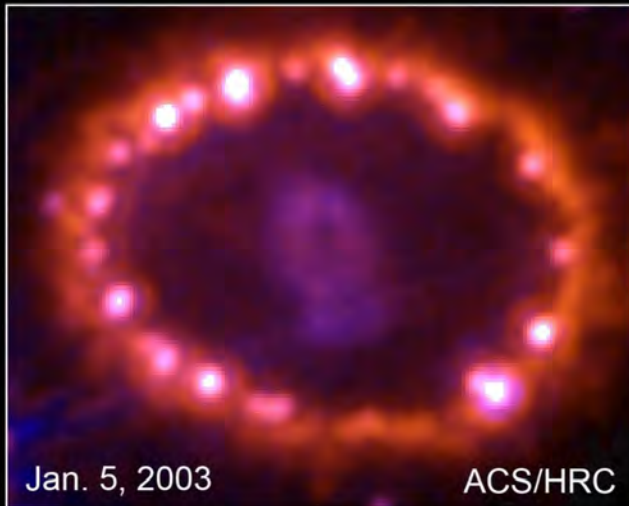
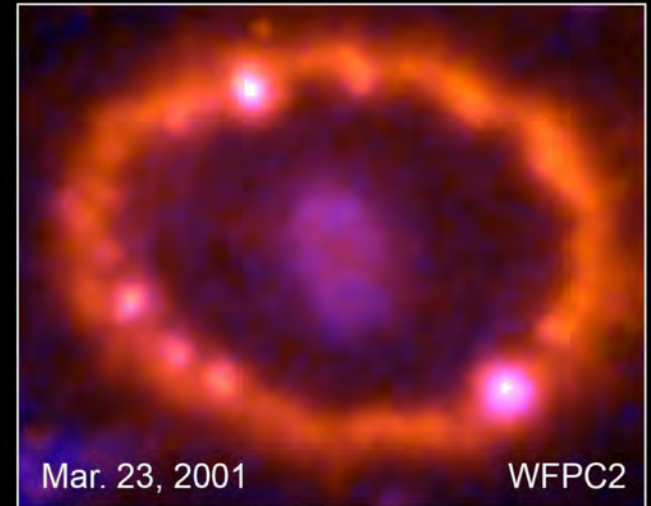
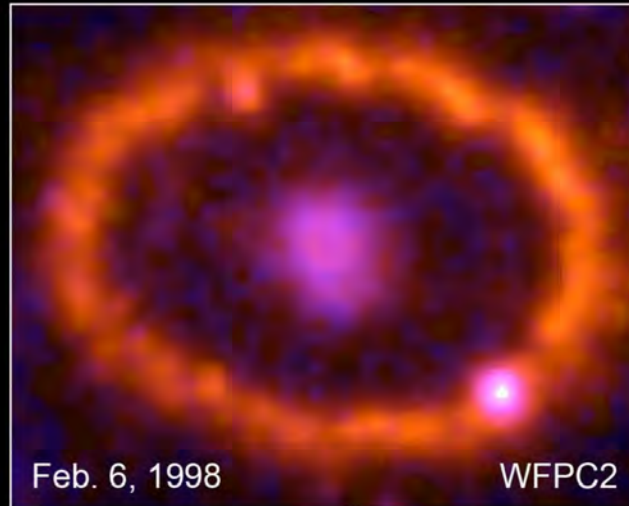
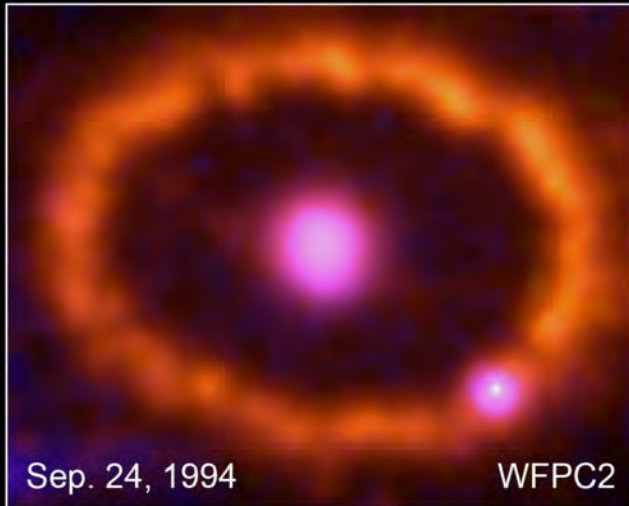
Top: M81 spiral galaxy taken with the Spitzer Space Telescope **Credit:** NASA/JPL-Caltech/S. Willner. <http://www.spitzer.caltech.edu/Media/releases/ssc2003-06/ssc2003-06c.shtml>

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 1

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 27 | 28 | 29 | 30 | 1 Canada Day 1902: Kristian Birkeland begins 2nd auroral expedition | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Independence Day | 4 1911: George Johnstone Stoney dies. In 1874 he proposes the existence of the electron | 5 | 6 | 7 | 8 | 9 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 Battle of Boyne Day (N. Ireland) | 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 | <table style="width: 100%; border: none;"> <tr> <td colspan="5" style="text-align: center;">June</td> <td colspan="7" style="text-align: center;">August</td> </tr> <tr> <td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td> </tr> <tr> <td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</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>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td> <td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td> </tr> <tr> <td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td> <td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td> </tr> <tr> <td>27</td><td>28</td><td>29</td><td>30</td><td></td><td></td><td></td> <td>29</td><td>30</td><td>31</td><td></td><td></td><td></td><td></td> </tr> </table> | | June | | | | | August | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 27 | 28 | 29 | 30 | | | | 29 | 30 | 31 | | | | |
| June | | | | | August | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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.

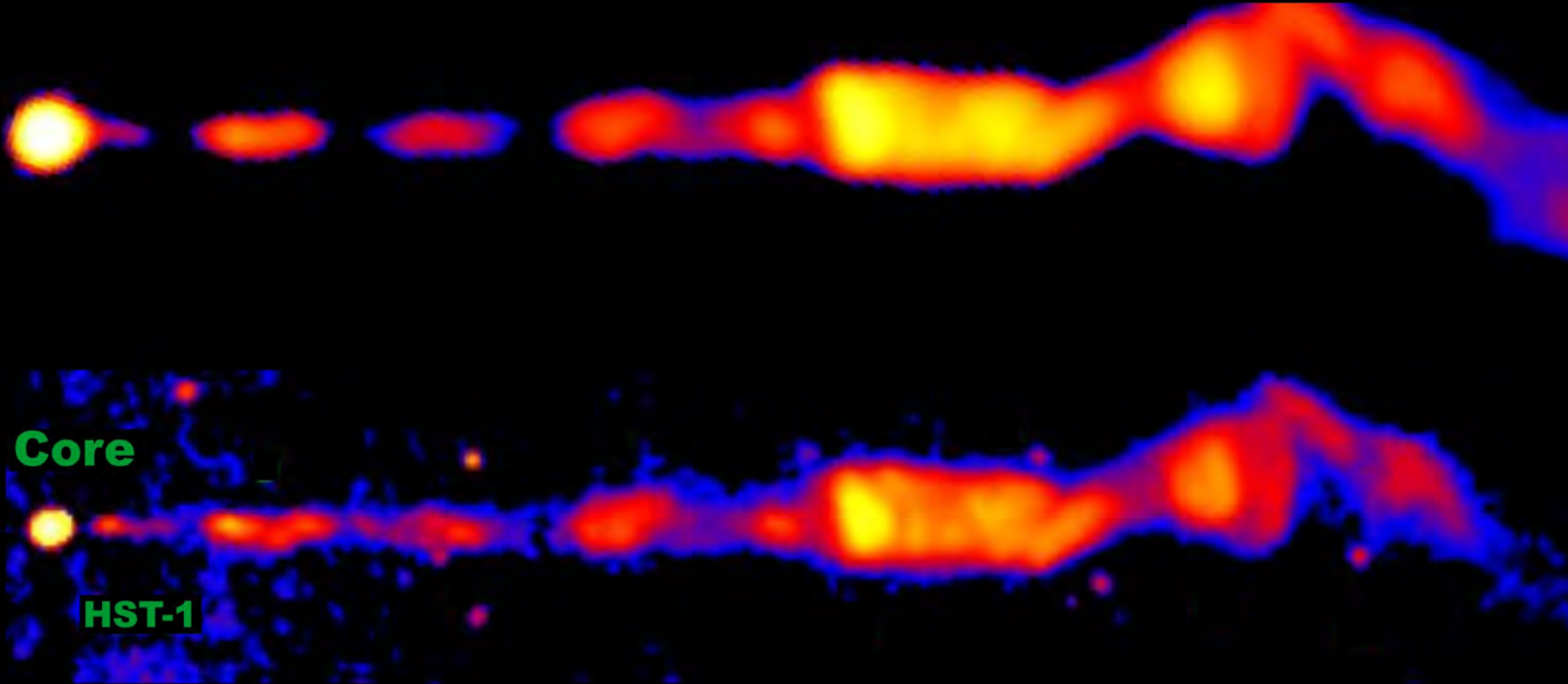
In the laboratory, a **beam** of "solid" charged particles may evolve into a hollow cylinder, the ring further subdividing into individual filamentary currents that may also pair up; see the witness foil (left) about 0.1 mm across.

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 1

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--------|--|-----------|----------|--------|---|--------|--|--|------|---|----|----|----|----|----|-----------|------|---|---|---|--|--|--|-----------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|---|--|--|--|--|---|---|---|---|--|---|---|---|---|---|---|----|--|--|--|--|---|---|---|---|---|----|----|--|----|----|----|----|----|----|----|--|--|--|--|----|----|----|----|----|----|----|--|----|----|----|----|----|----|----|--|--|--|--|----|----|----|----|----|----|----|--|----|----|----|----|----|----|----|--|--|--|--|----|----|----|----|----|--|--|
| Holiday (Scotland) 1928: Irving Langmuir coins the word "plasma" | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 15 | 1957: Irving Langmuir, pioneer dies | 17 | 18 | 19 | 20 | 21 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1879: William Crookes discovers "radiant matter" | 22 | 23 | 24 | 25 | 26 | 27 | 28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Late Summer Bank Holiday | 29 | 1871: Ernest Rutherford born; discovers the proton in 1918 | 31 | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | 6 | 7 | 8 | 9 | <table style="margin: auto; border: none;"> <tr> <td colspan="10"></td> <td colspan="3" style="text-align: center;">July</td> <td colspan="4"></td> <td colspan="4" style="text-align: center;">September</td> </tr> <tr> <td colspan="10"></td> <td></td> <td>1</td> <td>2</td> <td>3</td> <td colspan="4"></td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td></td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td colspan="4"></td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td>11</td> </tr> <tr> <td></td> <td>11</td> <td>12</td> <td>13</td> <td>14</td> <td>15</td> <td>16</td> <td>17</td> <td colspan="4"></td> <td>12</td> <td>13</td> <td>14</td> <td>15</td> <td>16</td> <td>17</td> <td>18</td> </tr> <tr> <td></td> <td>18</td> <td>19</td> <td>20</td> <td>21</td> <td>22</td> <td>23</td> <td>24</td> <td colspan="4"></td> <td>19</td> <td>20</td> <td>21</td> <td>22</td> <td>23</td> <td>24</td> <td>25</td> </tr> <tr> <td></td> <td>25</td> <td>26</td> <td>27</td> <td>28</td> <td>29</td> <td>30</td> <td>31</td> <td colspan="4"></td> <td>26</td> <td>27</td> <td>28</td> <td>29</td> <td>30</td> <td colspan="2"></td> </tr> </table> | | | | | | | | | | | | July | | | | | | | September | | | | | | | | | | | | | | | 1 | 2 | 3 | | | | | 1 | 2 | 3 | 4 | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | | | | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | | | | 19 | 20 | 21 | 22 | 23 | 24 | 25 | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | 26 | 27 | 28 | 29 | 30 | | |
| | | | | | | | | | | July | | | | | | | September | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | 1 | 2 | 3 | | | | | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | | | | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | | | | 19 | 20 | 21 | 22 | 23 | 24 | 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | 26 | 27 | 28 | 29 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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

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

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 29 | 30 | 31 | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Labor Day | 5 | 6 | 7 | 8 | 9 | 10 | Patriot Day Grandparent's Day | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 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 | <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p style="text-align: center; margin: 0;">August</p> <table style="font-size: small; margin: 0;"> <tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr> <tr><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td></tr> <tr><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td></tr> <tr><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td></tr> <tr><td>29</td><td>30</td><td>31</td><td></td><td></td><td></td><td></td></tr> </table> </div> <div style="width: 45%;"> <p style="text-align: center; margin: 0;">October</p> <table style="font-size: small; margin: 0;"> <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> <tr><td>31</td><td></td><td></td><td></td><td></td><td></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 | 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 | 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 | 31 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

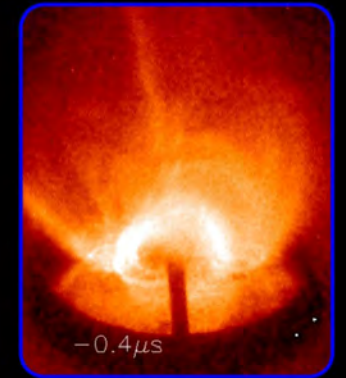
1987: Willard Harrison Bennett, pioneer dies

1870: Georges Claude born. In 1910 he displays the first neon lamp

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 1

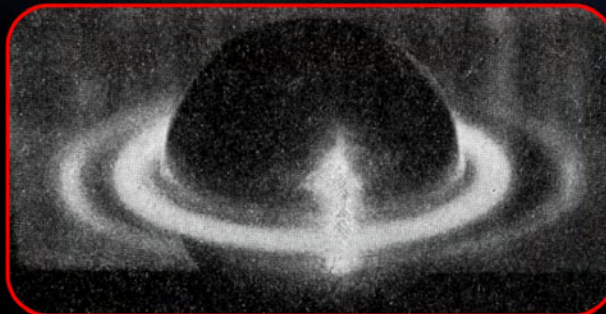
| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | |
|--|---|---|----------|--|--|--------|----|--------------------------|----|
| <p>September</p> <p>1 2 3 4</p> <p>5 6 7 8 9 10 11</p> <p>12 13 14 15 16 17 18</p> <p>19 20 21 22 23 24 25</p> <p>26 27 28 29 30</p> | <p>November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

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 1

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 31 | All Saints Day 1 | All Souls Day 2 | 3 | 4 | 1879: James Clerk Maxwell, pioneer dies Guy Fawkes Day 5 | Daylight Savings Time Ends 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Election Day 8 | 9 | 10 | Veteran's Day 11 | 12 | Remembrance Day 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | 15 | 16 | 1607: Northern Lights seen over Europe, and described by Johannes Kepler 17 | 18 | 19 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | 22 | 23 | Thanksgiving 24 | 25 | 26 | 27 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | 29 | St. Andrew's Day 30 | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 6 | 7 | 8 | 9 | <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;"> <p>October</p> <table border="1"> <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> <tr><td>31</td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table> </div> <div style="text-align: center;"> <p>December</p> <table border="1"> <tr><td></td><td></td><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><td></td><td></td></tr> <tr><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td></td><td></td></tr> <tr><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td></td><td></td></tr> <tr><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td></td><td></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 | 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 | 31 | | | | |
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| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | 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 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.

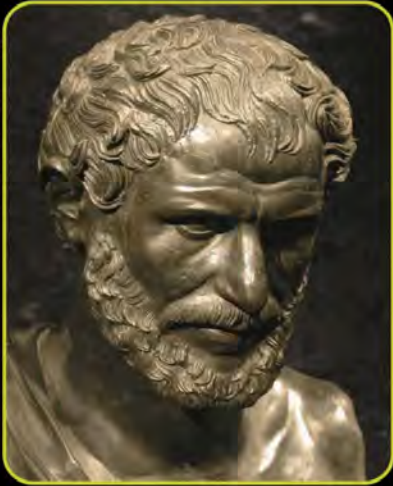
<http://hubblesite.org/newscenter/archive/releases/2002/24/image/a/>

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

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 28 | 29 | 30 | 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 1867: Kristian Birkeland, plasma pioneer born | 13 | 14 | 15 | 16 | 17 | 18 1856: Sir J J Thomson, pioneer born | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 19 | 20 | Hanukkah Winter Solstice | 21 | 22 | 23 Christmas Eve | 24 25 Christmas Christmas Day | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Boxing Day Kwanzaa | 26 | 27 | 28 | 29 1979: Charles Bruce, electrical engineer, dies | 30 | 31 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | 3 | 4 | 5 | 6 | <table style="width: 100%; border: none;"> <tr> <td colspan="6" style="text-align: center;">November</td> <td colspan="6" style="text-align: center;">January</td> </tr> <tr> <td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> <td></td><td></td><td></td><td></td><td></td><td>1</td> </tr> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td> <td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td> </tr> <tr> <td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td> <td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td> </tr> <tr> <td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td> <td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td> </tr> <tr> <td>28</td><td>29</td><td>30</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>29</td> </tr> <tr> <td></td><td></td><td></td><td></td><td></td><td></td><td></td> <td>30</td><td>31</td><td></td><td></td><td></td><td></td><td></td> </tr> </table> | | November | | | | | | January | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | 1 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 28 | 29 | 30 | | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | | | | | | 30 | 31 | | | | | |
| November | | | | | | January | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | 29 | 30 | | | | | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 30 | 31 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

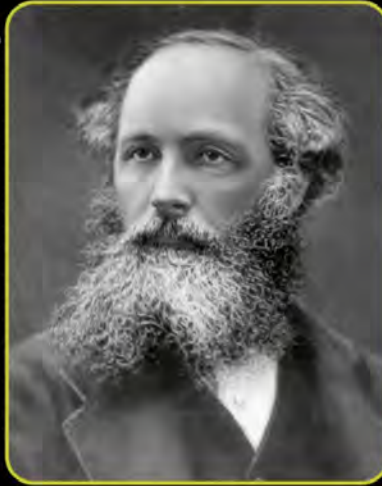
Plasma Universe pioneers

Source: Livius.Org.



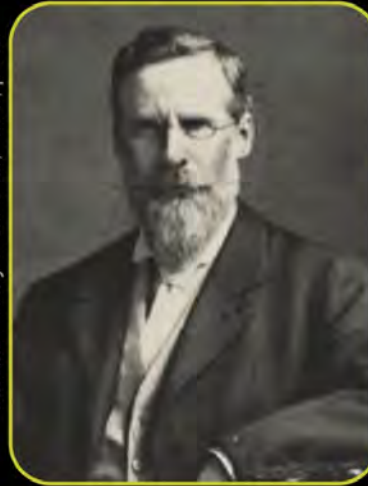
Heraclitus of Ephesus (540–475 BC) noted that: ". the thunderbolt steers the course of all things"

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.

2010
Plasma Universe
Calendar

www.plasma-universe.com

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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

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J A N U A R Y 2 0 1 2

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