

## Space Weather

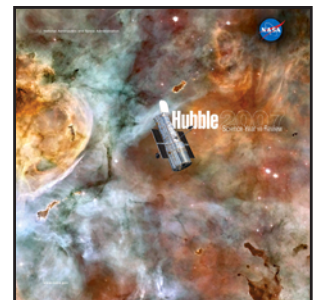
John T. Clarke

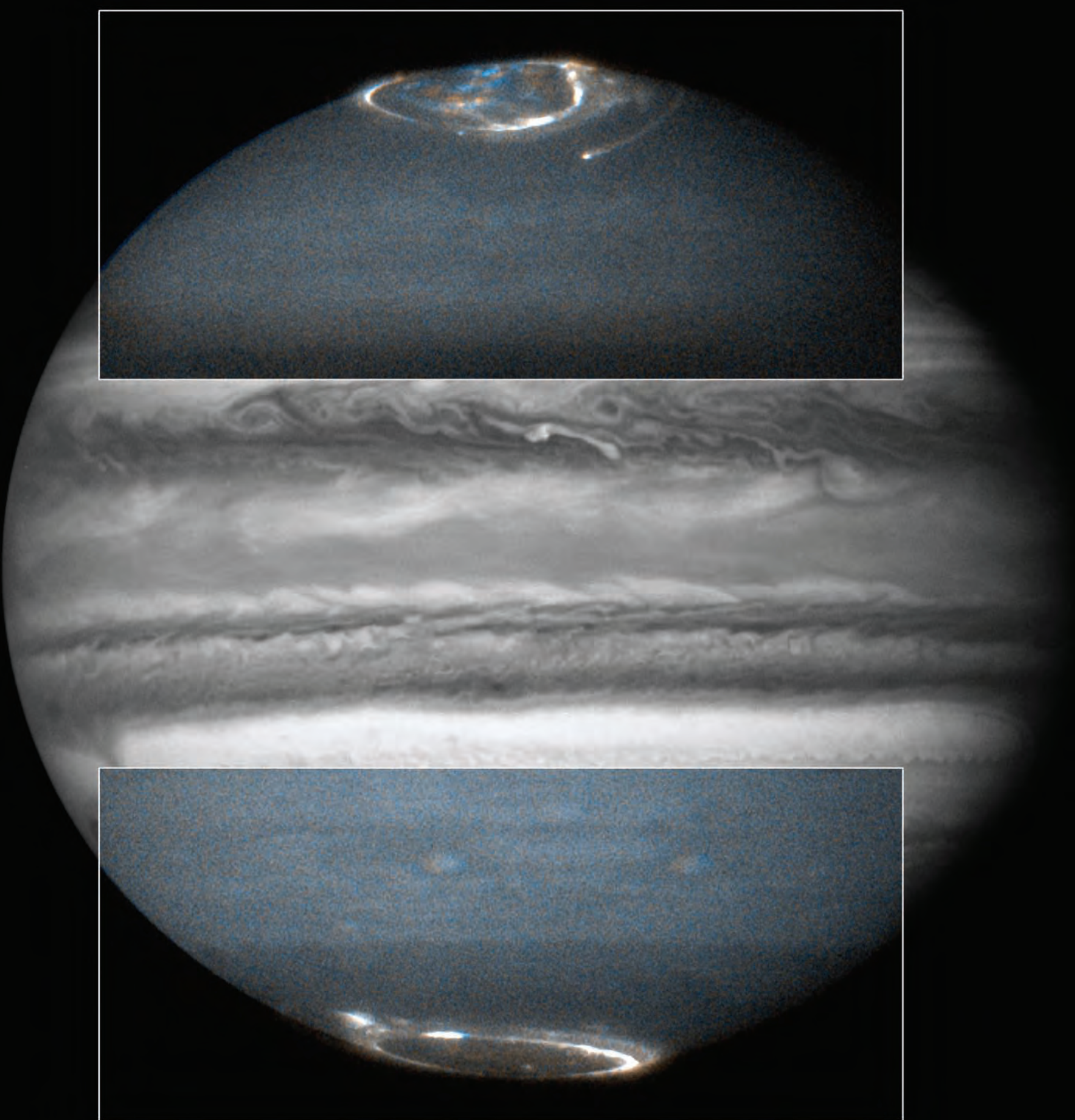
### Taken from: Hubble 2007: Science Year in Review

Produced by NASA Goddard Space Flight Center and Space Telescope Science Institute.

The full contents of this book include more Hubble science articles, an overview of the telescope, and more. The complete volume and its component sections are available for download online at:

[www.hubblesite.org/hubble\\_discoveries/science\\_year\\_in\\_review](http://www.hubblesite.org/hubble_discoveries/science_year_in_review)





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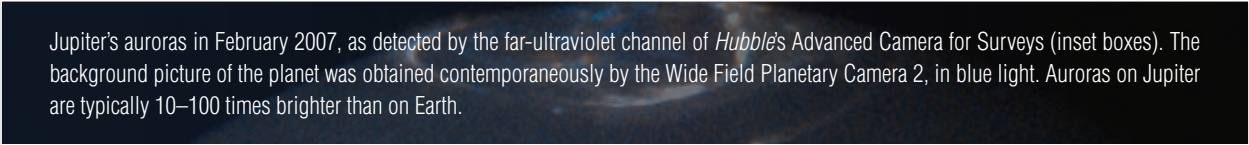
*John T. Clarke*

The United Nations declared 2007 as an International Heliophysical Year (IHY). Scientists worldwide coordinated diverse studies of the forces and factors that influence planetary environments. Notable among these are planetary magnetic fields, which govern the effects of charged particles from the Sun on planetary atmospheres, and give rise to auroras. *Hubble* contributed to IHY by observing auroras on Jupiter and Saturn, seeking clues about the role of the Sun in driving these spectacular displays.

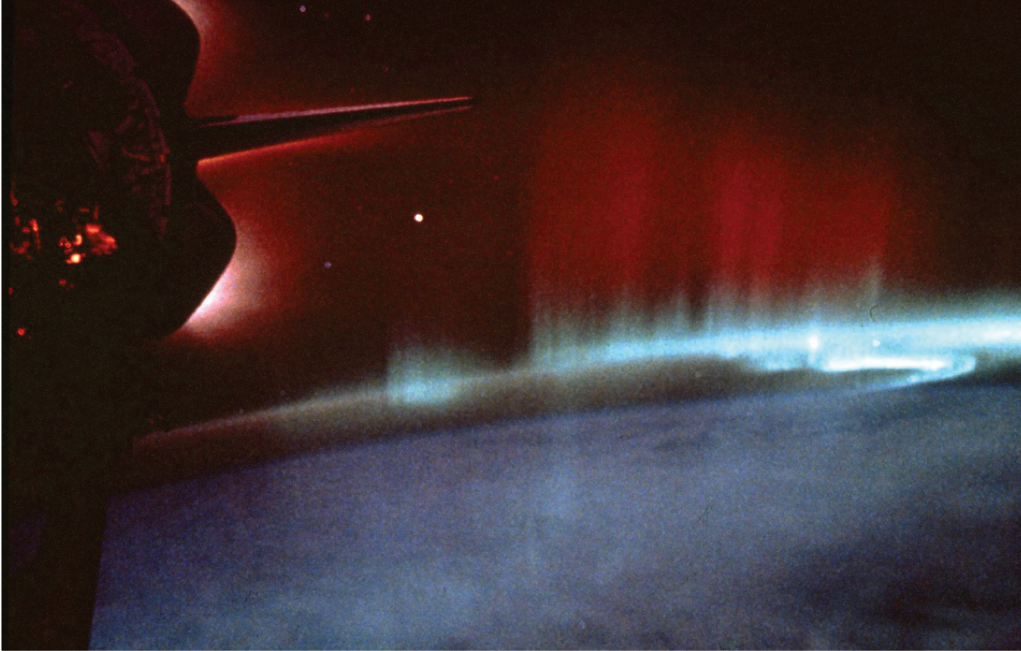
On Earth, people living at high northern or southern latitudes see auroras as vast, enveloping curtains of ghostly color quivering in the dark sky. They have learned that major occurrences often follow reports of eruptions on the Sun by a few days. Such eruptions intensify the flood of charged particles emanating from the Sun and flowing outwards through space toward the Earth and the other planets. When this “solar wind” arrives at Earth, a fraction of the charged particles are injected into the huge electrical circuit “wired” by the Earth’s magnetic field. The only visible aspects are the rings of auroras that may appear near the poles, where the circuit closes in the atmosphere. When they are excited by collisions with the charged particles, atmospheric molecules produce the auroras’ light.

Everyday life on Earth can be affected during intense auroras. If the surge of electricity is particularly strong, satellite communications may be disrupted, and parts of the electrical power grid may shut down. Such is the drama of “space weather”—phenomena caused by the ebb and flow of charged particles through the magnetic structures of the Solar System.

Space weather touches all the planets, not just Earth. Strong auroras occur on Jupiter and Saturn, too, which also possess robust, global, electrical circuits, due to their strong magnetic fields. From its remote vantage point and simultaneous view of both polar regions, *Hubble* can observe the auroras of these planets with a synoptic perspective. *Hubble* can also detect ultraviolet light from planetary auroras, which is not possible from the ground, because of the absorption of the Earth’s atmosphere. Viewing in the ultraviolet has a two-fold advantage: the brightness of the planetary disk is reduced, and the aurora itself is brighter. These factors greatly increase contrast and visibility.



Jupiter’s auroras in February 2007, as detected by the far-ultraviolet channel of *Hubble*’s Advanced Camera for Surveys (inset boxes). The background picture of the planet was obtained contemporaneously by the Wide Field Planetary Camera 2, in blue light. Auroras on Jupiter are typically 10–100 times brighter than on Earth.



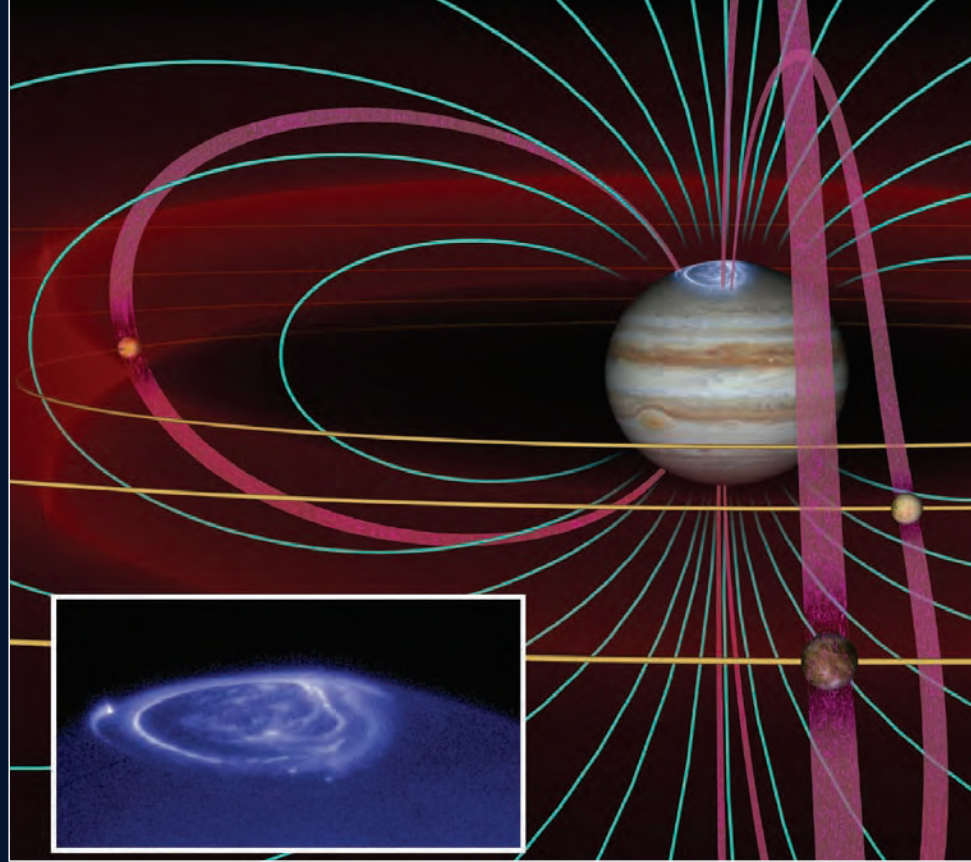
Earth's aurora as observed by astronauts aboard the Space Shuttle. The red and blue curtains of light are due to molecules of nitrogen and oxygen, respectively, excited by charged particles. The emissions begin about 60 miles above the ground, where the incoming charged particles begin to collide with atmospheric molecules.

In the case of Earth, satellites and ground-based instruments continually monitor the local solar wind and all aspects of the auroras. Such coordinated observations have solidly established that variations in the solar wind are mainly responsible for our auroral storms. However, the degree of correlation has been unknown for other planets, because of the absence of instruments to measure the solar wind at those locations. Nevertheless, a special opportunity arose in February 2007, when the *New Horizons* spacecraft flew past Jupiter on its way to Pluto. At that time, *Hubble* observed Jupiter's auroras while *New Horizons* measured the local charged particles. Similarly, *Hubble* observed Saturn's auroras while the orbiting *Cassini* spacecraft studied the planet's magnetic field and charged-particle environment.

The *Hubble* observations of Jupiter began on February 20. On February 28, a significant brightening and displacement of the auroras was detected. It occurred at the same time *New Horizons* detected a major increase in the local solar wind.

It is not clear why changes in the solar wind should match changes in the Jupiter auroras, as they do in the case of Earth. At the much greater distance from the Sun, the solar wind is far weaker than at the Earth. Furthermore, the much stronger magnetic field of Jupiter should resist the impinging solar wind more effectively than is the case for Earth.

Cartoon of the magnetic field of Jupiter (turquoise), which creates electric circuits that connect the solar wind and polar auroras (inset). Circuits passing through Jupiter's satellites are special cases that can produce enhanced auroras (magenta).



### Summary

During the IHY, scientists studied space weather at Jupiter and Saturn using coordinated observations by *Hubble*, *New Horizons*, and *Cassini*. By comparing the effects of the space environment on various planets, they can better understand the Earth as a habitat for life. In the future, we expect such studies to provide insight into the conditions on the many extrasolar planets now being discovered around nearby stars.



John T. Clarke is a professor in the Center for Space Physics at Boston University. He was born in Chicago, attended Denison University in Ohio, and obtained a Ph.D. in physics from the Johns Hopkins University in Maryland. He worked for NASA as a project scientist on *Hubble* before the launch, and has also worked at space science laboratories in Berkeley, California, and Ann Arbor, Michigan.