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EDITORIAL

Uncovering the Secrets of the Gas Giant

Alessandro Mura

INAF—Istituto di Astrofisica e Planetologia Spaziali, Rome, 00133, Italy

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If we want to keep our Earth habitable, we must strive to know as much as possible about all its less fortunate "brother" planets. Like novice students of "planetary physiology", we must study the sick to learn how to stay healthy. It is necessary to understand how planets have evolved, whether some of them have been potentially habitable in the past, how the four smallest rocky ones have been guided in their evolution by the four gas or icy giants. Among these last ones, Jupiter is the protagonist. All theories about the birth and evolution of the Solar System revolve around its "personal history", because it is probably the first to form and therefore the one that has influenced others more than any other planet.

Although much can be understood about a planet just by remote observation, direct exploration offers us otherwise unattainable information. We can study its gravity and internal structure, its magnetic field, its environment; we have the possibility of observing regions not visible from Earth, such as the poles. At the end of the 1970s, after the fly-by of the Pioneer 10 probe, NASA began designing a mission entirely dedicated to Jupiter: Galileo. After Galileo, whose scientific results were partly compromised by some technical problems, it was Juno's turn, launched in 2011 and in orbit around Jupiter since 2016.

Named after the consort of the Roman god, the Juno probe observes the planet Jupiter completely, scrutinizing him even beneath its thick layer of clouds. Equipped with a suite of instruments, including plasma and field detectors, cameras, a magnetometer, a microwave radiometer and a gravity science experiment, Juno has been able to peer beneath the planet's thick clouds and provide a detailed view of its atmosphere, it's interior and the environment around the planet [1]. Juno has shed new light on the planet's interior, revealing that Jupiter's core is larger and more diffuse ("fuzzy") than previously thought. This finding has important implications for our understanding

*Corresponding Author:
Alessandro Mura,
INAF—Istituto di Astrofisica e Planetologia Spaziali, Rome, 00133, Italy;
Email: alessandro.mura@inaf.it

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of how gas giants like Jupiter form and evolve over time.

One of the first discoveries made by Juno is the existence of two huge, stable cyclone systems at both planets' poles. The two polar cyclones, which are thousands of kilometres wide, are surrounded by an octagon of cyclones in the North, and by a pentagon in the South. While scientists are still trying to understand why this unusual configuration exists, it has been recently found that the cyclones are quite stable, with a lifetime of tens to hundreds of years [2].

Outside the polar regions, the fast east-west jet streams, separating the iconic belts and zones, have been found to be quite deep. The measurements of gravitational harmonics indicate that these streams have a vertical extension of thousands of kilometres (~3000) beneath the reference level of 1 bar [3]. That depth, magnetic dissipation could occur, and this is an example of the existing link between the magnetic field and the atmospheric winds. Another one has been found in the vicinity of the Great Blue Spot, which is an anomalous intensification of magnetic flux close to the equator. Since Juno is constantly monitoring the configuration of the magnetic field of Jupiter, it is possible to analyse its temporal variability, which suggests a significant advection of the magnetic field by deep zonal winds close to this Great Blue Spot. This is, again, consistent with the penetration of zonal winds to a depth of ~3,500 km [4].

Finally, recent measurements of Jupiter's gravity field showed that its gaseous envelope is inhomogeneous, with its interior enriched in heavy elements, surrounding a fuzzy core. Since such enrichment should have continued during the gas accretion phase of Jupiter formation, this poses constraints on models and theories for the formation of giant planets (and hence the whole Solar System) [5].

Juno is now waiting for two other missions that will contribute to our understanding of Jupiter. The first one is the European Space Agency's (ESA) Jupiter Icy Moons Explorer (JUICE), launched in April 2023. This ambitious mission will study Jupiter's icy moons, including Europa, Ganymede, and Callisto, which are believed to harbour subsurface oceans that may be capable of supporting life. JUICE will use a suite of instruments to study the composition, geology, and potential habitability of these moons, as well as the interactions between the moons and the planet's magnetic field.

The other is the upcoming Europa Clipper mission, which is set to launch in the mid 2020s. This is a NASA mission that will study Jupiter's moon Europa, which is believed to be one of the most promising places in the solar system to search for signs of life. The Europa Clipper mission will conduct a detailed survey of Europa's surface and environment, using a suite of instruments to search for signs of life and study the moon's geology and composition.

In conclusion, the recent developments in Jupiter exploration have given us a fascinating glimpse into the complex world of this gas giant. From the Juno mission's detailed study of Jupiter's atmosphere and magnetic field to the upcoming JUICE and Europa Clipper missions, we are learning more and more about the processes that shape this enigmatic world. With each new mission and discovery, we are unlocking the secrets of Jupiter and expanding our understanding of the solar system and our place within it.

Conflict of Interest

The author declares no conflicts of interest.

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