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The icy moons of the outer Solar System: A global perspective

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The grand tour of the outer Solar System by the Pioneer and the Voyager spacecraft in the 1970s began an era of unprecedented data gathering about the gas giants, their rings and their moons. In the last four decades, much has been learned about their compositions, atmospheric dynamics, internal structures, magnetospheres, evolution and other characteristics, and the detailed images those spacecraft relayed to the Earth continue to leave us spellbound even today.

In the 1990s a few more missions, of a more reduced scope, followed Voyager to the gas giants: Galileo and Ulysses to Jupiter, and more recently Cassini-Huygens to Saturn and its moon Titan. In total, in the last 40 years planetary spacecraft have visited Jupiter 8 times, Saturn 5 times, and Uranus and Neptune once. Pluto has never been visited, although NASA's New Horizons spacecraft is on its way to Pluto and Charon, which it should reach in 2015. Of all the missions sent to the gas giants, only two, Galileo and Cassini-Huygens, remained in orbit around the planet, and released and "landed" a probe (on Jupiter and on Titan).

One of the most outstanding outcomes of this suite of missions has been the discovery of the astonishing variety, in nature and in appearance (i.e. surface features), of the different moons orbiting these planets, the great majority of which are icy moons. But even more outstanding is the fact that the icy moons, for a long time believed to be dead frozen worlds, in many cases have shown an unexpected and surprising level of activity (cryovolcanism, recent resurfacing, a dense atmosphere interacting with the surface...). And in some cases evidence has been found for the existence of possible subsurface liquid oceans, with important implications for astrobiology.

This paper aims at reviewing and summarizing the results of all these robotic missions, to give a global perspective on what we have seen and learned so far about the icy moons. It focuses with a greater level of detail on surface processes and compositions, as well as on theories of moon formation. Only objects with a radius equal or greater than 200 km are considered, and –except for Pluto and Charon- Edgeworth-Kuiper belt objects are not discussed. From this global perspective a rationale for further scientific study of the icy moons of the Solar System is derived, and the need for increased public outreach is defended.

We have just begun to "skim the surface" of these moons, but they have already shown to be fascinating worlds full of surprises, a case study in themselves. The implementation of new concept missions to the outer planets, like the joint NASA/ESA Europa-Jupiter System Mission (EJSM), and the arrival of New Horizons at Pluto, will take us a step further in unveiling their mysteries.