A Brief Post-Cassini Review of the Ring-Atmosphere Interaction at Saturn

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The rings of Saturn had attracted the attention of astronomers since the time of Galileo. But the recognition of the complex nature and time-changing behavior of the ring system had to wait until the close flyby observations of the Voyager 1 and 2 spacecraft in November, 1980, and August, 1981, respectively. Not just the fine-scale structures of the ringlets were amazing to see; the sharp edges of the outer A-ring, both sides of the Cassini division and the inner B-ring were also found to be an integral part of the majestic architecture that is the Saturnian ring system. Another totally curious fact was about the finding that the planetary magnetic field of Saturn is perfectly dipole-like except for a small shift of the center of the magnetic moment. Very intriguing radial features of dust clouds appeared from time to time during the rapid crossings of the Voyager spacecraft. These observational recipes have fed into the imagination of a number of plasma physicists and atmospheric scientists leading to the picture of constant injection of charged nano-dust particles of icy composition into the Saturnian ionosphere. This theoretical model or rather a collection of such models of dusty plasma dynamics would predict the formation of the sharp B-C ring boundary and the depletion of the ionospheric electron density via the so-called “ring rain” effect.

The radio occultation measurements of the Cassini spacecraft provided very valuable information on the Saturnian ionospheric profile. It is interesting to note that, while the “ring rain” effect as a consequence of gravito-electrodynamical instability would predict electron depletion at mid-latitude region with magnetic connection to the C-ring, the electron depletion detected by the radio science experiment showed up repeatedly at the equatorial and low-latitude region. The Grand Finale of the Cassini mission in 2017 with 22 fly-throughs of the no-man’s land between the inner edge of the D ring and Saturn’s upper atmosphere with closest approach at 2000 km above the 1-bar pressure level, until its final plunge on September 14, 2017, was therefore the climax of our long quest of the origin and dynamical evolution of the rings of which the dusty plasma effect could play a fundamental role. As of May, 2018, many of the very interesting, new results are still being reviewed and compared. We hope to be able to give a preliminary view of the once-upon-a-lifetime Cassini findings in contrast to the post-Voyager ideas as an invitation to new ideas from the young generation of the post-Cassini era.