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New Horizons REX Radiometry at Pluto and Charon

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Abstract

The New Horizons Radio Science Experiment (REX), included measurements of the radio thermal emission from Pluto and Charon (wavelength: 4.2 cm) during the encounter on 14 July 2015. The radiometry observations with highest resolution occurred shortly after closest approach, when the high gain antenna (HGA) was scanned diametrically across Pluto and back again over the winter pole. Nightside observations of Pluto and Charon were performed complimentarily with the REX radio occultation experiment in the interval between ingress and egress, i.e. at times when the planetary disk blocked the uplink signals used for atmospheric sounding. Brightness temperature measurements of the unresolved disk of both bodies were performed on the dayside (pre-encounter) and nightside (post-encounter). We present the observations and provide preliminary interpretations of the measured brightness temperatures.

1. Introduction

The prime science objective of the REX instrument was to determine the surface pressure on Pluto and the temperature structure of the lower atmosphere [6]. Height profiles of density, pressure, and temperature were derived from phase delay measurements of radio signals transmitted from Earth during Pluto occultation [2]. The Pluto ionosphere could not be detected from these same phase delay data, but a significant upper bound to the peak electron density of 1000 cm^{-3} could be derived [3]. Another important part of the REX investigation, the subject of this work, was the measurement of the thermal emission from the solid bodies Pluto and Charon, at the nominal spacecraft uplink wavelength. A description of the calibration of the REX instrument for radiometry [4], as well as interim reports of the observations have been published elsewhere [1,5].

2. REX Radiometry Observations

REX radiometry measurements of radio flux density are recorded with two independent receivers: REX A (right circularly polarization – RCP) and REX B (left circularly polarization – LCP) at a rate of 10 samples per second. The REX radiometry measurements show the presence of broad regions of differing microwave brightness, constraining volatile transport models and providing insight into the properties and structure of the materials on Pluto.

2.1 High-Resolution Thermal Scan

Figure 1 shows the variation in radio flux density (units: kJy) observed during the thermal scans across the Pluto disk shortly after closest approach to Pluto (diametric scan: upper panel; polar scan: lower panel). Only REX A is plotted; the REX B scan is virtually identical. The HGA boresight offset from the disk center is indicated along the upper abscissa axis. The spatial resolution at the midpoint of the diametric scan was 288 km (3 dB beam diameter). The vertical dashed lines mark the times when the HGA boresight crossed the day/night terminator and the Pluto limbs (inbound and outbound). Both scans were found to have their maximum radio flux density on the nightside as well as a distinct kink in the profile at the terminator. These effects can arise either from actual physical temperature differences or differences in the emissivity of the subsurface source material.

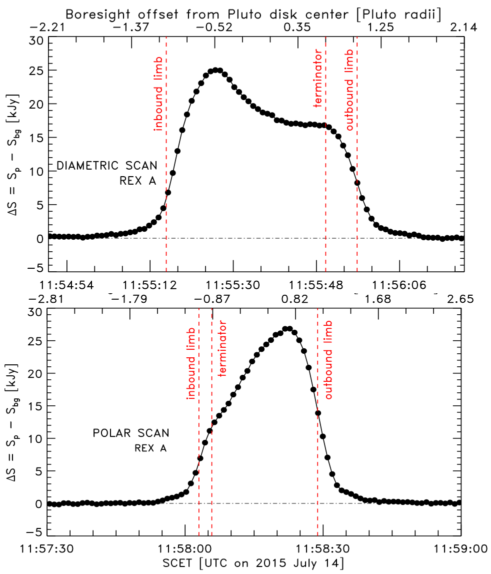

Figure 1: Variation in radio flux density above the backgroound during the thermal scans shortly after the closest approach of New Horizons to Pluto (upper panel: diametric scan; lower: polar scan).

2.2 Nightside Scans

Figure 2 presents the brightness temperatures derived from REX radiometry observations between radio occultation ingress and egress (upper panel: Pluto; lower panel Charon). The distance of the HGA boresight from the disk center in Pluto/Charon radii is denoted on the upper abscissa axis. Whereas the average diameter of the HGA 3 dB beam for the Pluto scan was ≈ 1100 km on the surface (i.e. crudely resolved), the disk of Charon was not resolved. Owing to the proximity of Sun and Earth as seen from New Horizons, the Sun rose above the planetary disk a few seconds before the end of the Earth occultation. Vertical dashed lines mark the sunrise event and the additional solar contribution to the measured radio flux density after this event has been subtracted out. The Pluto profile, most of which covers regions of the surface not covered by the other instruments on New Horizons, has its maximum brightness temperature of ~ 29 K near the center of the scan and decreases toward both limbs. The variations on scales of a few 100 km (tenths of a Pluto radius) are real and can be produced by differences in the subsurface temperature and/or emissivity. The unresolved Charon scan, in contrast, yields only a single value for the brightness temperature near 41 K.

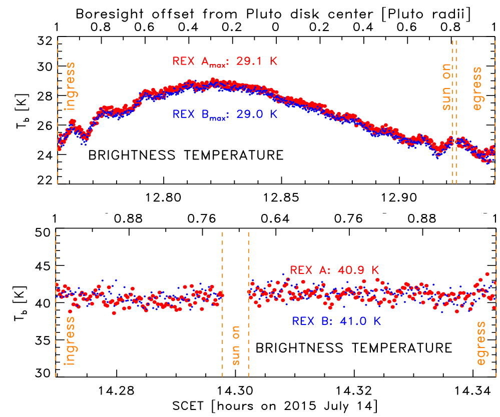

Figure 2: Brightness temperature during the nightside scans of Pluto (upper panel) and Charon (lower panel).

3. Summary

The thermal radio emission at 4.2 cm from Pluto and Charon was measured by radiometry observations as part of the REX investigation on New Horizons. As expected from its higher optical albedo, Charon was determined to be distinctly warmer than Pluto. The thermal emission from the dayside of both bodies was found to be stronger than on the nightside.

References

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