RESEARCH ARTICLE SUMMARY

PLANETARY SCIENCE

Pluto's interaction with its space environment: Solar wind, energetic particles, and dust

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INTRODUCTION: The scientific objectives of NASA's New Horizons mission include quantifying the rate at which atmospheric gases are escaping Pluto and describing its interaction with the surrounding space environment. The two New Horizons instruments that measure charged particles are the Solar Wind Around Pluto (SWAP) instrument and the Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instrument. The Venetia Burney Student Dust Counter (SDC) counts the micrometer-sized dust grains that hit the detectors mounted on the ram direction of the spacecraft. This paper describes preliminary results from these three instruments when New Horizons flew past Pluto in July 2015 at a distance of 32.9 astronomical units (AU) from the Sun.

RATIONALE: Initial studies of the solar wind interaction with Pluto's atmosphere suggested that the extent of the interaction depends on whether the atmospheric escape flux is strong (producing a comet-like interaction, where the interaction region is dominated by ion pick-up and is many times larger than the object) or weak (producing a Mars-like interaction dominated by ionospheric currents with limited upstream pick-up and where the scale size is comparable to the object). Before the New Horizons flyby, the estimates of the atmospheric escape rate ranged from as low as 1.5×10^{25} molecules s^{-1} to as high as 2×10^{28} molecules s^{-1}. Combining these wide-ranging predictions of atmospheric escape rates with Voyager and New Horizons observations of extensive variability of the solar wind at 33 AU produced estimates of the scale of the interaction region that spanned all the way from 7 to 1000 Pluto radii (R_P).

RESULTS: At the time of the flyby, SWAP measured the solar wind conditions near Pluto to be nearly constant and stronger than usual. The abnormally high solar wind density and associated pressures for this distance are likely due to a relatively strong traveling interplanetary shock that passed over the spacecraft 5 days earlier. Heavy ions picked up sunward from Pluto should mass-load and slow the solar wind. However, there is no evidence of such solar wind slowing in the SWAP data taken as near as ~20 R_P inbound, which suggests that very few atmospheric molecules are escaping upstream and becoming ionized. The reorientation of the spacecraft to enable imaging of the Pluto system meant that both the SWAP and PEPSSI instruments were turned away from the solar direction, thus complicating our analysis of the particle data. Nevertheless, when the spacecraft was ~10 R_P from Pluto, SWAP data indicated that the solar wind had slowed by ~20%. We use these measurements to estimate a distance of ~6 R_P for the 20% slowing location directly upstream of Pluto. At this time, PEPSSI detected an enhancement of ions with energies in the kilo–electron volt range. The SDC, which measures grains with radii >1.4 µm, detected one candidate impact in ±5 days around its closest approach, indicating a dust density estimate of n = 1.2 km^{-3}, with a 90% confidence level range of $0.6 < n < 4.6$ km^{-3}.

CONCLUSION: New Horizons's particle instruments revealed an interaction region confined sunward of Pluto to within ~6 R_P. The surprisingly small size is consistent with a reduced atmospheric escape rate of 6×10^{25} CH_4 molecules s^{-1}, as well as a particularly high solar wind flux due to a passing compression region. This region is similar in scale to the solar wind interaction with Mars's escaping atmosphere. Beyond Pluto, the disturbance persists to distances greater than 400 R_P downstream. ■

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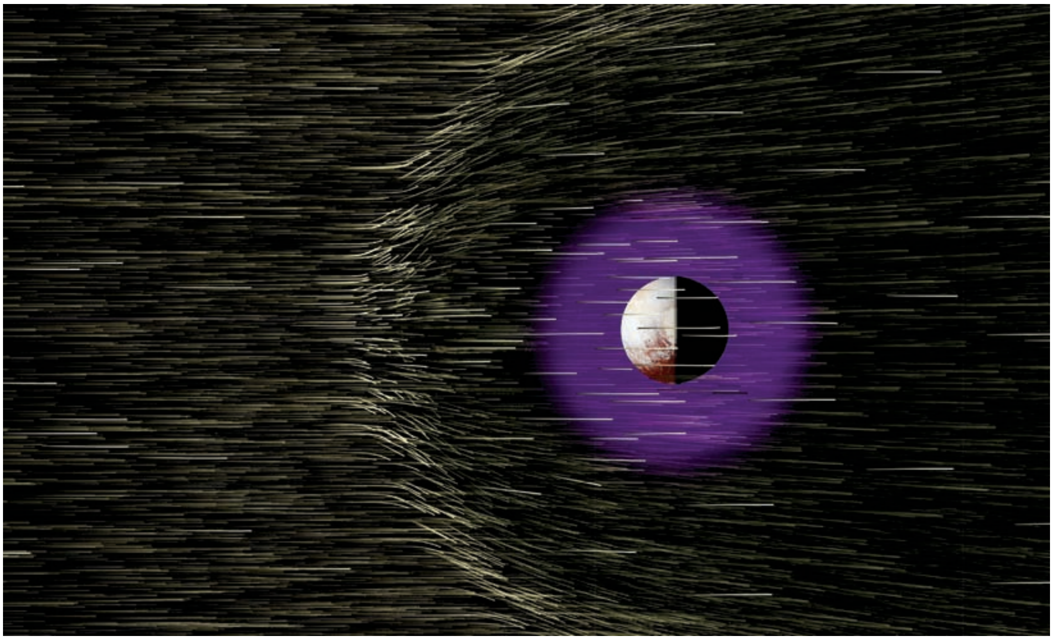

Interaction of the solar wind with Pluto's extended atmosphere. Protons and electrons streaming from the Sun at ~400 km s^{-1} are slowed and deflected around Pluto because of a combination of ionization of Pluto's atmosphere and electrical currents induced in Pluto's ionosphere.

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