New Horizons Observations of Energetic Particles in the Outer Heliosphere

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New Horizons, launched in 2006, is a planetary mission to study Pluto and Kuiper belt objects. Besides very high-value contributions to planetary science and the paradigm-shifting discoveries at Pluto and Arrokoth, it has also provided much valuable science to heliophysics community. New Horizons is now located at about 55 au from the Sun, beyond the densest region of the Kuiper belt, exploring the outer heliosphere. It is the only spacecraft equipped with proper instruments to measure nonthermal energetic pickup ions (PUIs) in the outer heliosphere for the first time. PUIs, created in the heliosphere by charge exchange between solar wind ions and interstellar neutral atoms, play an essential role in understanding solar wind evolution in the outer heliosphere and the structure and dynamics of the global heliosphere. New Horizons observations showed that energetic PUIs dominate the internal pressure of the outer heliosphere, with PUI pressures larger than the thermal solar wind and magnetic pressures outside ~ 20 au [1,2]. At these distances, PUIs contribute substantially to heating and slowing down the solar wind. Moreover, it showed that nonthermal PUIs mediate shocks in the outer heliosphere [3,4]. Here, we give an overview of the energetic particles in the outer heliosphere and their effect on shocks. We present in situ observations of the hydrogen and Helium PUIs made by New Horizons' SWAP [5] and PEPSSI instruments [6,7]. Finally, we present some of the most important open questions related to the dynamics and global structure of the outer heliosphere that future studies and space missions should address.

References:
[1]: McComas, D. J., Zirnstein, E. J., Bzowski, M., et al. 2017, ApJS, 233, 8
[2]: McComas, D. J., Swaczyna P., Szalay, J. R., et al. 2021, ApJS, 254, 19
[3]: Zirnstein, E. J., Kim, T. K., Mostafavi, P., et al.2020, The Astrophysical Journal, 891, 56
[4]: McComas D. J., Shrestha B. L., Swaczyna P., Rankin J. S., et al. 2022, ApJ 934 147
[5]: McComas, D., Allegrini, F., Bagenal, F., et al. 2008, SSRv, 140, 261
[6]: McNutt, R. L., Livi, S. A., Gurnee, R. S., et al. 2008, SSRv, 140, 315
[7]: Kollmann, P., Hill, M. E., McNutt, R. L., et al. 2019, ApJ, 876, 46