PLASMA SPECTROMETER TO CHARACTERIZE THE ENVIRONMENT OF APOPHIS. REUSAGE OF THE INSTRUMENT PEP/JEI ON JUICE ONBOARD THE RAMSES MISSION. N. Krupp[1], M. Fränz[1], E. Roussos[1], T. Kleine[1], and S. Barabash[2], [1]Max Planck Institute for Solar System Research/MPS (Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany, krupp@mps.mpg.de), [2] Swedish Institute of Space Physics/IRF (Bengt Hultqvists väg 1, 981 92 Kiruna, Schweden, Stas@irf.se)

Introduction: The flyby of asteroid 99942 Apophis in 2029 offers the unique opportunity to study the interaction of an asteroid with the Earth magnetosphere (see also the accompanying abstract by Barabash et al.). By measuring the spatial and energy distribution of positive and negative particles in close proximity to the asteroid it is possible to get significant information about the object without landing on it or without returning a sample from it. Fundamental questions like the investigation of the plasma interaction on different scales or the formation of a plasma wake and plasma expansion into vacuum can be studied. By characterizing the environment of an asteroid, we can also learn if the interaction is similar or totally different compared to the processes near the Earth's moon.

Full information is revealed if the particle properties impacting the surface of the object as well as all the various types of particles released from the surface e.g., backscattered and sputtered particles, photoelectrons, secondary electrons, charged dust, and neutral particles are measured [1]. There is evidence that the number density of those particles and their energy distribution reveal information on the structure of the surface regolith [2,3]. Together with computer simulations on similar types of asteroids [4] the obtained information is essential for the study of Near Earth Objects like Apophis.

Unique Opportunity of the Apophis flyby 2029: The flyby of Apophis near Earth is special in many ways. First, the flyby geometry is unique with a closest approach of about 31000 km at the edge or inside the outer radiation belt which can vary between 13000 km to 60000 km dependent on solar cycle and solar wind activity during the flyby period. This offers the unique opportunity to study the interaction of Apophis with the solar wind before the closest approach as well as the interaction with conditions inside the Earth's radiation belts. Besides electrons and protons, the outer belt also contains He^{2+} and O^{+}- ions. These conditions in the Earth magnetic field of about 300-350 nT are similar to the conditions inside Jupiter's magnetosphere between Europa and Ganymede. Secondly, the low relative velocity between the asteroid and Earth offers the opportunity to get very close to the object or even drop a landing probe on it with a minimum effort of energy compared to other flyby scenarios further away from Earth.

Unique opportunity of the RAMSES mission flying a plasma instrument onboard: The unique possibility of the RAMSES mission compared to all the other missions currently planned to fly by Apophis is that it will carry a plasma spectrometer. None of the other missions have such a type of an instrument! It can be used to characterize the interaction of the local plasma with the object (space weathering of the regolith) by determining the plasma parameters in the vicinity of the object (velocity, density, temperature, electrostatic potential and surface charging [5,6], electric field, ion composition) as a function of distance from the asteroid.

Usage of the plasma spectrometer JUICE PEP/JEI flight spare for RAMSES: Given the tight time schedule to reach Apophis in April 2029 it is mandatory for flyby missions like RAMSES to integrate an already existing plasma spectrometer with a high TRL-level. We offer the fully space qualified and fully tested flight spare unit of the plasma spectrometer JEI (Jovian Electron and Ion sensor; part of the Particle Environment Package PEP, currently on its way to Jupiter onboard the Juice mission launched in April 2023). PEP/JEI has TRL-level 9 and can measure ions and electrons in the energy range 2eV-60 keV/charge within 4s and from nearly all directions of one hemisphere (azimuth directions 360 degrees; polar directions up to 82 degrees). These instrument parameters are fully adequate to meet all the science goals described above.

References: [1] Stubbs, T. J., et al. (2014) Planetary and Space Science 90: 10-27. [2] Romain Canu-Blot et al., (2024), Astronomy & Astrophysics manuscript no. comet 67P_backscattered_protons ″ESO 2024 January 31, 2024. [3] Wekhof, A. (1981). The Moon and the Planets 24, 45–52. https://doi.org/10.1007/BF00897567

[4] Lianghai Xie et al. (2023), The Astrophysical Journal, 952:61 (6pp). [5] Llera et al. (2020), Geophysical Research Letters, 47, e2019GL086147.https://doi.org/10.1029/2019GL086147. [6] Halekas, J. S. et al. (2007), *Geophys. Res. Lett.*, 34, L02111, doi:10.1029/2006GL028517.