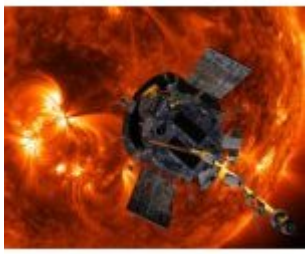
First discoveries of the Parker Solar Probe mission



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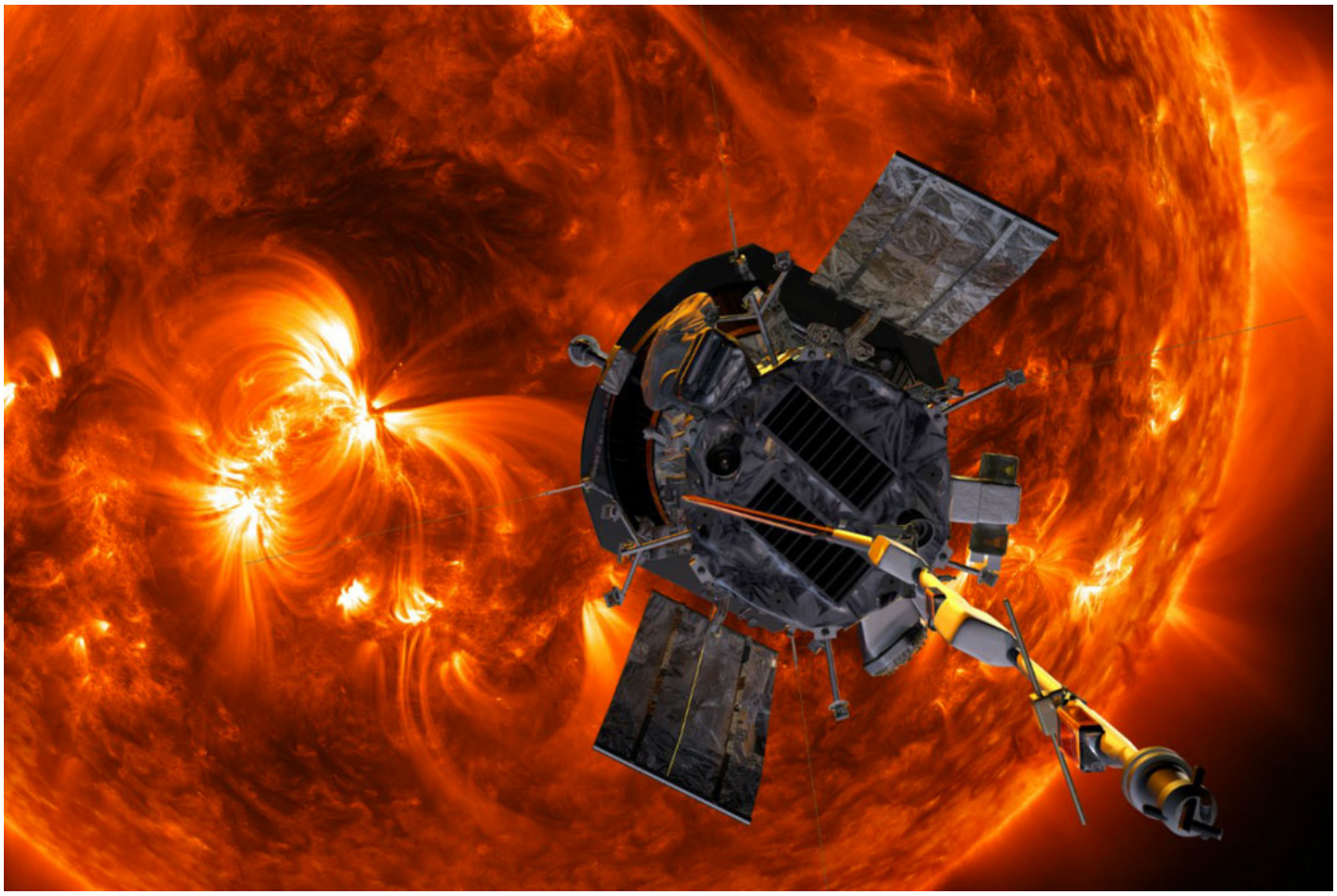
Observatoire de Paris - PSL Centre de recherche en astronomie et astrophysique

The analysis of the first results from NASA's Parker Solar Probe mission, in which participated the Plasma Physics laboratory (CNRS/École Polytechnique/Observatoire de Paris/Université Paris-Sud/Sorbonne Université) has been published in the December 4th 2019 issue of Nature. The analysis bears witness to large amplitude increases in the solar wind, which could play a role in the heating of the solar corona, and reveals also an unexpectedly large do-rotation of plasma with the Sun.



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The dream of Icarus is in some sense realized with the analysis of the first results of the Parker Solar Probe mission, in which has participated the Laboratoire de Physique des Plasmas (the Plasma Physics Laboratory). ntly From the ten ideas of the missions defined in 1958 at the very beginning of the space era, the solar probe was the last unit to be added to this constantly evolving structure. Since then all sorts of challenges have been realized, we have walked on the Moon, but never before had we «touched the Sun».

After many aborted attempts, a realistic project was born in 2010 and became a NASA project, launched in August 12th 2018 as the Parker Solar Probe, the fasterst ever space probe. It carries only 4 instruments so as to reduce the mass of the probe and maximize its speed, so that it can get as close as possible to the Sun without falling into its gravitational well.

The challenge is impressive, since its purpose is to solve the mystery of how the solar corona is heated: the temperature of the corona is on the order of 2 million degrees, way beyond that measured at the solar surface, which is about 6 000 degrees. While a number of mechanisms have been suggested, no measurements had been made beyond 65 solar radii to confirm or not these mechanisms.

This has now been done, thanks to the Parker Solar Probe, which carries in particular two electron spectrometers having an extremely compact detector based on that designed by the LPP for the European Solar Orbiter mission.

With the support of the CNES, the «Space Plasma» team designed the integrated electron detector circuit. Able to function in the extreme radiation rich environment close to the Sun, it is much more economical in energy usage than any of the systems used till now, and so it has been possible to miniaturize the mission's electron spectrometers.

The paper published in the Decmeber 4th 2019 issue of Nature details the surprising discovery of well structured solar wind within which appear solar wind surges virtually constgantly during the two weeks when the probe went very close to the Sun, to 35 solar radii for the first two analyzed orbits.

The speed of the solar wind is seen to jump suddenly from 300 to 450 km/sec, its density virtually doubles, and the direction of the magnetic field, while relatively intense in the solar neighbourhood, can reverse its direction. The data from the electron spectrometers shows that the magnetic connections to the Sun do not change, which raises questions as to their origin.

It is no less surprising that these jumps in the solar wind are accompanied by a very high speed transverse plasma wind which can be as high as 30 à 50 km/sec, i.e. over 15 times higher than the highest co-rotation speed in the solar corona. The associated angular momentum loss, if it is confirmed, will have to be explained, and will have to be confronted with stellar evolutionary models.

These first results signal the start of a particularly fascinating campaign of measurments, for which the probe's perihelion will be lowered to less than 10 solar radii before 2024, using the gravity of the planet Mercury.

Reference

- Kasper, J.C., Bale, S.D., Belcher, J.W., Berthomier, M. et al. Alfvénic velocity spikes and rotational flows in the near-Sun solar wind. Nature (2019) doi:10.1038/s41586-019-1813-z

French contributions to the Parker Solar Probe

The five French laboratories contributing to the Parker Solar Probe are:

- l'Institut de recherche en astrophysique et planétologie (CNRS/Université Paul Sabatier Toulouse III/CNES),
- le Laboratoire d'études spatiales et d'instrumentation en astrophysique (CNRS/Observatoire de Paris/Sorbonne Université/Université de Paris),
- le Laboratoire de physique et chimie de l'environnement et de l'espace (CNRS/CNES/Université d'Orléans),
- le Laboratoire de physique des plasmas (CNRS/École Polytechnique/Observatoire de Paris/Université Paris-Sud/Sorbonne Université)

- le laboratoire Procédés, matériaux et énergie solaire du CNRS.

