# Report on the second SHOTS group meeting in Kiruna

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| Dates of visit | 11.09.2018-17.09.2018 |
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**Expert Program report**

Thanks to an exception and the following second approval of the expert program of EUROPLANET, the second meeting of the new SHOTS project (Simulations in Hybrid and Other TheorieS) was held in mid September in Kiruna, Sweden. The SHOTS project was initially launched as an incentive to collectively test, benchmark and validate each of the SHOTS member's simulation codes that are used to research the interaction of the solar wind with the magnetosphere of planet Mercury. The different simulation "families" of magnetohydrodynamic (MHD), full-particle and hybrid codes have their own strengths and weaknesses as they focus on different interaction regions or processes. These simulation families have different numerical approaches to the same physical processes they want to address.

In the first SHOTS meeting in Meudon, Paris, we decided on normal sets of parameters which all simulation codes were to use for their simulation runs to disentangle the effects of the different numerical approaches. Within the months between the two meetings, multiple telecons have been done to analyze the results.

The simulation codes had all good agreement on the upstream bow shock and magnetopause positions. These boundaries are standing waves within the plasma to shock the solar wind plasma, decelerate it below super-alfvénic Mach numbers so that the plasma can flow around the obstacle. Also position and volume of the features like the polar cusps were generally in agreement with each others codes but differences became noticeable. Still, the day-side magnetosphere of Mercury is sufficiently in agreement with all codes.

However, when the magnetotail of the night-side magnetosphere was discussed, completely different results were obtained, see Figure 1. In this group meeting the two hybrid simulation groups (AMITIS from Kiruna, Sweden and AIKEF from Braunschweig, Germany) were able to meet and discuss their different results from their numerical approaches of the night-side magnetosphere.

We could pinpoint the different results to the different handling of the vacuum regions in Mercury's tail. Hybrid simulations are not able to self-sufficiently represent vacuum as magnetic fields need a medium to be carried through the simulation grid cells. The two major numerical approaches that are used in the simulation community for vacuum regions of planets, comets and moons are subsequently used by our codes, i.e. the insertion of "ghost"-ions in the vacuum regions (AIKEF, higher calculation and memory effort, better localization of currents) and the insertion of a conductivity profile in a vacuum cell (AMITIS, very fast, delocalized currents,). After telecons with the rest of the SHOTS group, we concluded that this "problem" occurs only with hybrid codes. The fluid aspect within MHD codes diminishes the formation of vacuum regions and the fast electron-particles in full-particle codes is able to carry the magnetic field just fine.

Further investigation into this -apparently- hybrid code problem in other planetary research fields yielded a perceived "ignorance" by other papers. Thus this hybrid issue has not been addressed within the scientific community, which we want to change through a new paper. We will perform dedicated parameter runs in ghost-ion density for the AIKEF and resistivity values for the AMITIS code respectively. We expect a certain range of parameters where the results are very similar and can calculate a function to express one parameter through the other.

In conclusion, the second SHOTS meeting was able to start another investigation of a research topic that was yet untouched. The results and

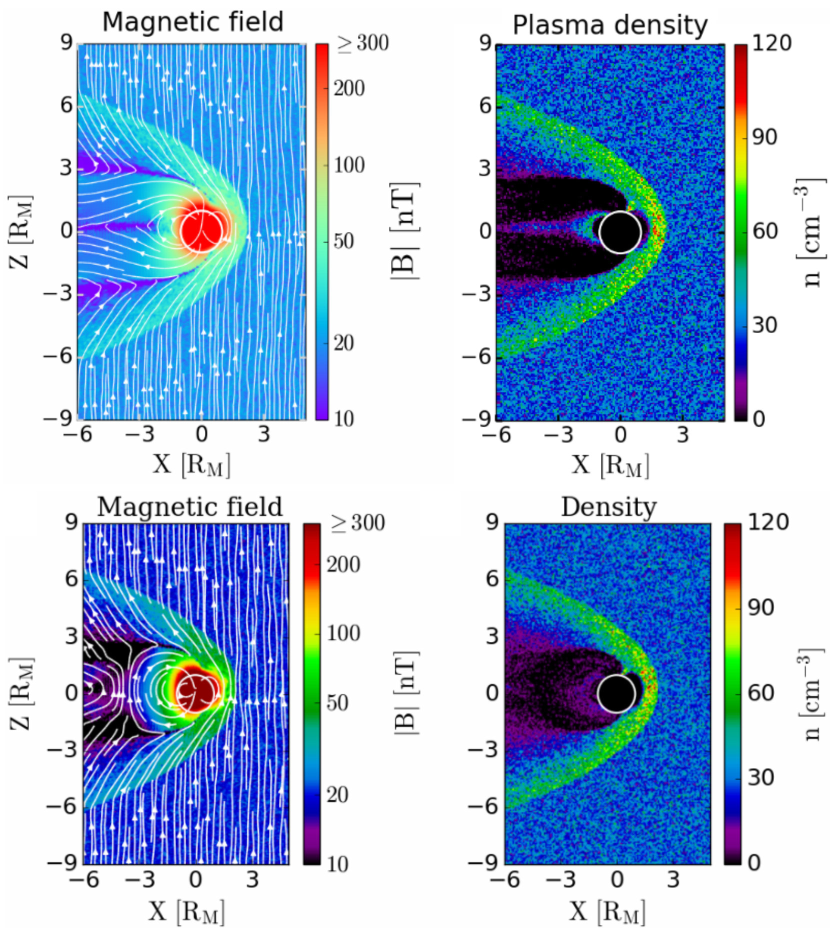


Figure 1: Different AMITIS results in the tail regions for different conductivity values within the vacuum regions in Mercury's magnetotail.

conclusions of the two SHOTS meetings will be presented in a poster talk (Poster number: P23F-2939) at the American Geophysical Union. We want to thank the EUROPLANET Expert Program for funding these meetings and enable this young research group to form and effectively work together.