

- We work on the physics of different solar system bodies by building on comparative planetology.
- We study the joint evolution of terrestrial planets by explaining their diverging paths as influenced by the same host star.
- We apply our research on various exoplanets including the evolution of Earth-like habitats.

MAIN RESEARCH QUESTIONS

- How does comparative planetology help to better understand the evolution of planets towards Earth-like habitats?
- How does stellar/solar activity impact planetary environments and what types of physics govern planetary evolution?
- What do planetary radio and plasma waves tell us about the plasma and magnetic field around a planet?
- How do electromagnetic emissions from an underground seismic source penetrate and disturb the atmosphere and ionosphere?
- How can we understand physical processes on icy surfaces?
- What properties of porous material on comet/asteroid surfaces are most significant for gas flow, and how do they influence the mass transport and thermal balance on the surface?

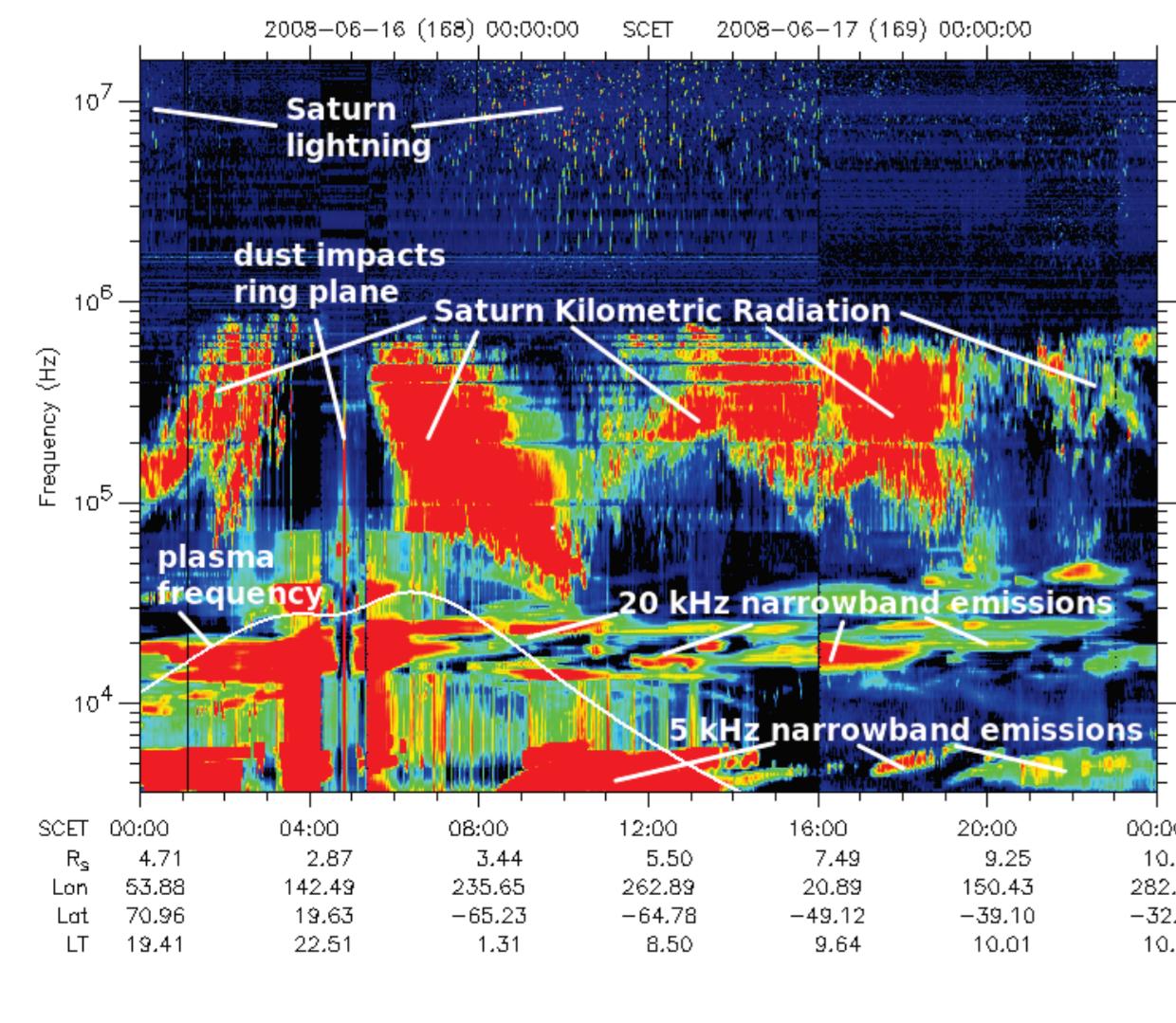
HOW COMMON ARE EARTH-LIKE HABITATS?

An Earth-like Habitat (EH) is defined as a rocky planet that orbits within the habitable zone of complex life and hosts an N₂-O₂-dominated atmosphere with minor amounts of CO₂. Aerobic complex lifeforms may not be able to exist on planets other than EHs and vice versa as the evolution of both is strongly interconnected. For such evolution certain geophysical and astrophysical conditions are necessary. This research is carried out within the framework of the PLATO mission.

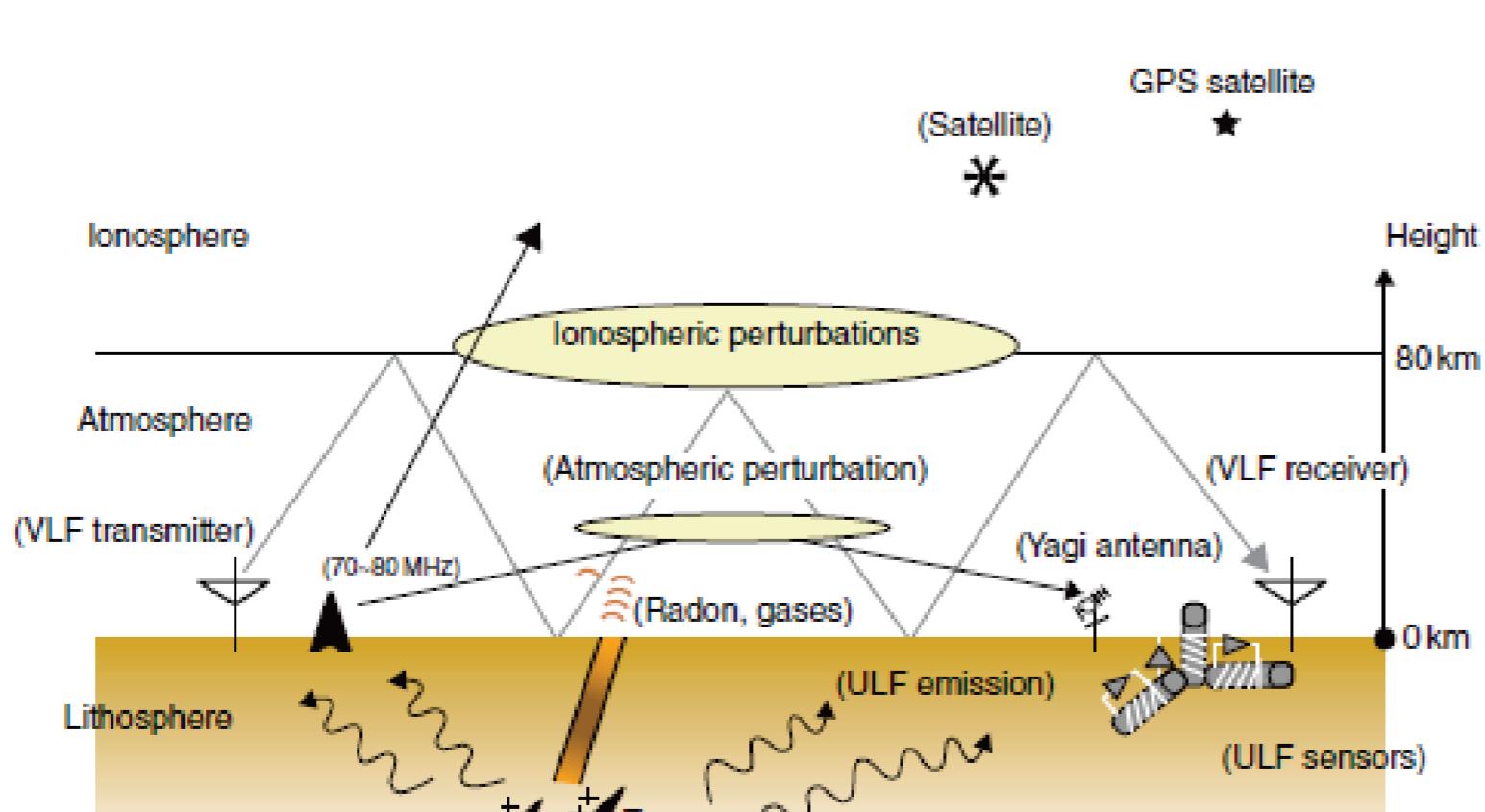
PLANETARY RADIO EMISSIONS

Light and radio emissions from the aurora not only occur at Earth, but also at the gas and ice giant planets in our solar system, and presumably also at exoplanets. Besides studying the properties and formation processes of radio emissions, we also calibrate spacecraft antenna systems. This was done for many missions (e.g., Cassini, Juno, STEREO, Solar Orbiter) and most recently for the radio wave antennas of the RPWI (Radio and Plasma Wave Investigation) instrument aboard JUICE.

At Earth, earthquakes create electrical charges, which generate seismo-electromagnetic waves that can be detected by satellites like China's CSES missions and ground-based antennas such as the INFREP network.



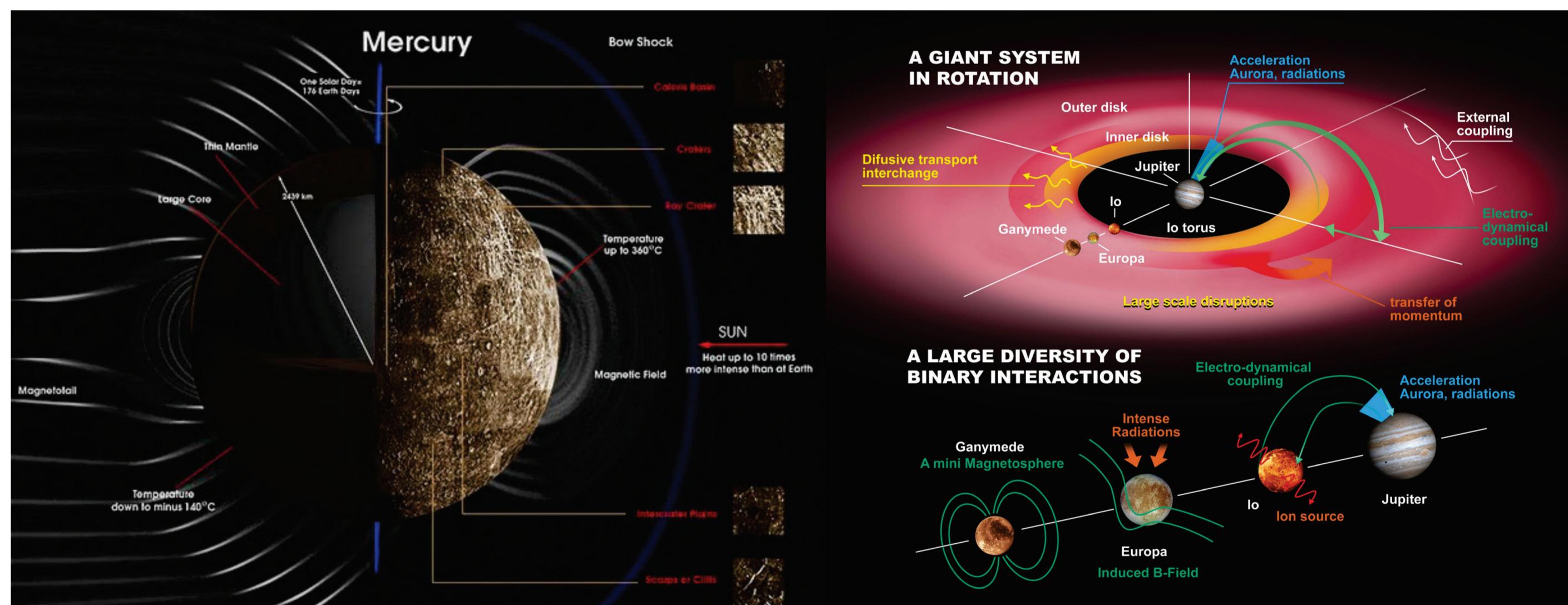
Typical Cassini radio spectrum showing the auroral Saturn Kilometric Radiation, Saturn lightning, and dust impacts from the ring plane.



Radio techniques developed to investigate physical processes from lithosphere-ionosphere coupling (e.g., seismo-electromagnetic waves from earthquakes).

FROM MERCURY TO ICY SATELLITES

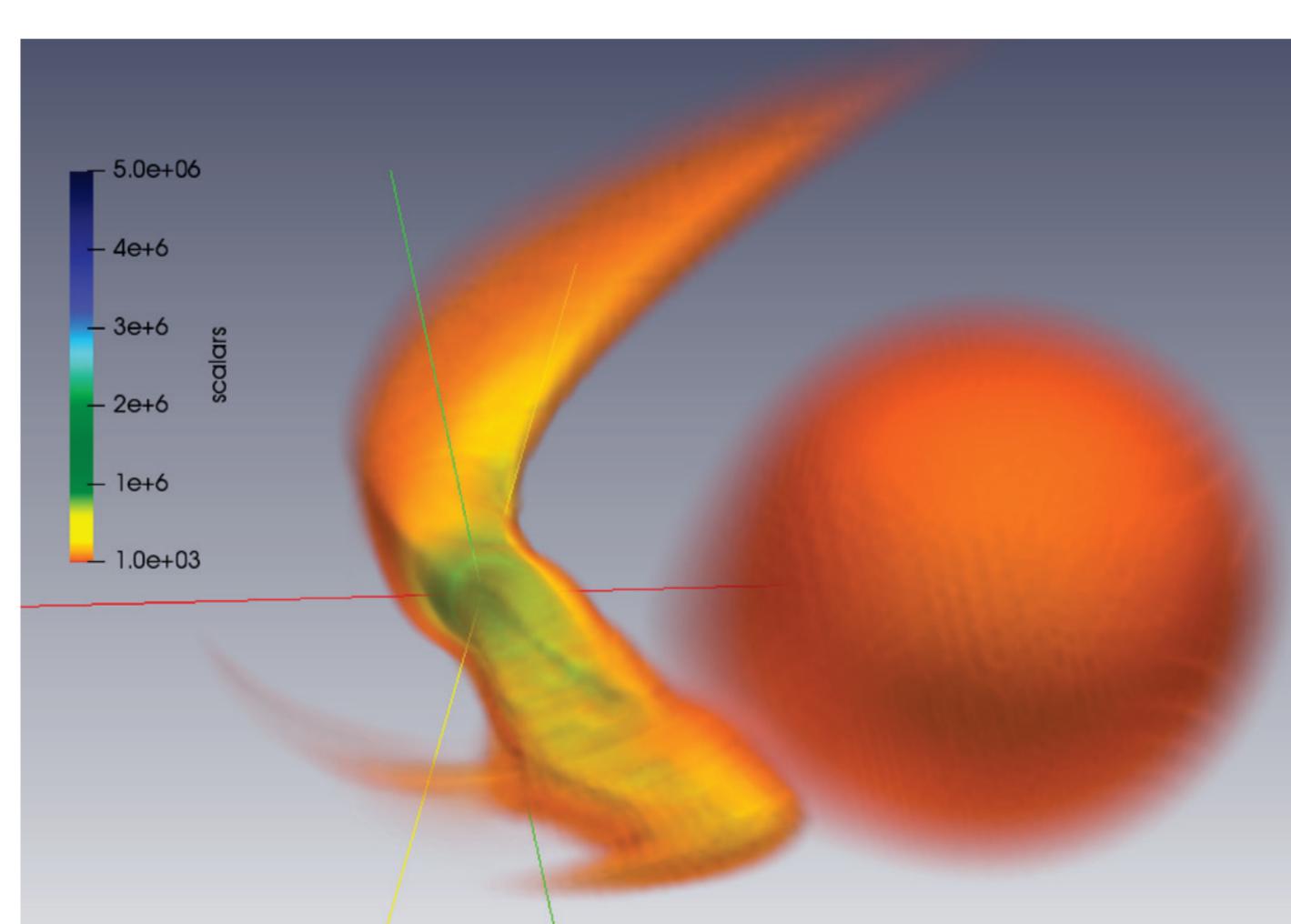
We study the formation of Mercury's silicate exosphere as originated through the solar plasma and radiation environment and investigate similar processes at icy satellites with the help of ESA's BepiColombo mission - with its PICAM (Planetary Ion CAMera) and SERENA instruments - and the JUpiter ICy moons Explorer (JUICE). We further study the evolution and water inventories at Venus, Earth and Mars.



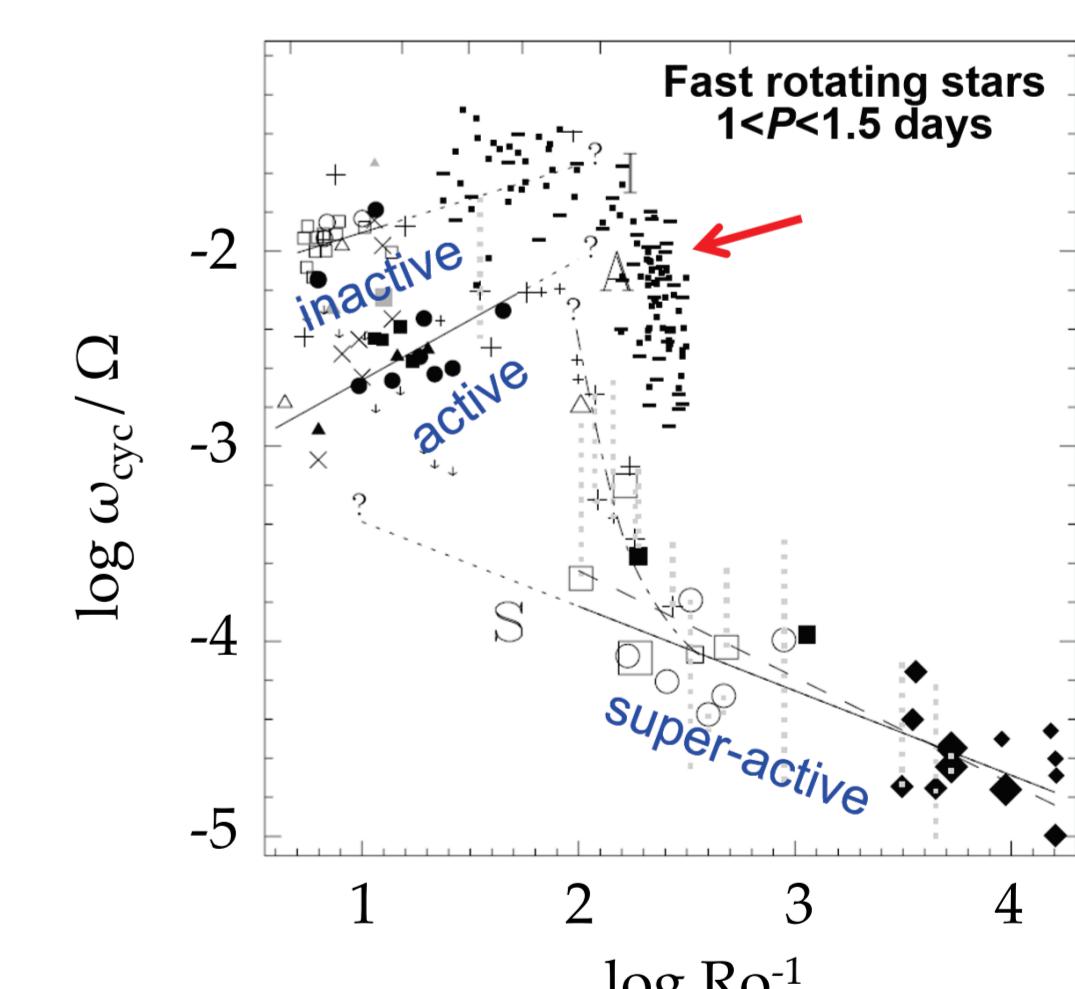
Plasma and radiative interaction with hot and icy surfaces (Credit: ESA)

STAR-MAGNETOSPHERE-PLANET INTERACTION

We implement a multidisciplinary approach to characterize and understand physical processes in the dynamical environments of (exo)planets, driven by complex star/Sun-planet interaction processes like stellar/solar activity, plasma flows, and radiation. Synergies between observations, laboratory experiments and theoretical models are used.



Outflowing H⁺ from hot Jupiter HD209458b, simulated with a dynamic 3D model.



Fast rotating stars connecting inactive and super-active stars.

ASTROLAB

We study the properties of porous surface materials on planets, asteroids, and comets. Thermal conductivity and the gas permeability of near-surface materials are decisive for thermal budgets surface-atmosphere interaction. These parameters are investigated in suitable vacuum chambers under well controlled conditions. Comparisons with observations support missions like Comet Interceptor and JUICE.



IWF's Astrolab