Modern Solar Physics: the power of simulations and observations.

Prof. Dr. R. Keppens

Centrum voor Plasma-Astrofysica, K.U.Leuven,
FOM-Instituut voor Plasma-Fysica Rijnhuizen,
Sterrenkundig Instituut, Universiteit Utrecht
Rony.Keppens@wis.kuleuven.be

Abstract

Our Sun plays a central role in modern astronomy, and is a huge plasma sphere, like any other star. Our closest stellar companion confronts us with many fascinating phenomena, and the central role played by magnetic fields in plasmas has become utterly evident from continuous solar observations. The images of the solar atmosphere became more impressive with each spacemission, and from Skylab (1973-1974), Solar Maximum Mission (1980-1989), Yohkoh (1991-2005), SOHO (1995-), TRACE (1998-), Hinode (2006-), . . . , we have learned that the 11-year solar cycle is a clear magnetic oscillation, and that the well-known Lorentz force can manifest itself in amazingly complex, but truly beautiful plasma dynamics. Alongside the continuous gain in the attained resolution of solar observations (now about 100 kilometer at best), another revolution happened within solar physics: the increased capabilities with respect to numerically simulating plasmaphysical phenomena. In that respect, a crucial role is played by the still growing computing capacities in research centres around the world, combined with sophisticated algorithms that allow us to capture the essential features of the Lorentz force in large-scale numerical simulations. This lecture will try to demonstrate this unique power of combining observations with simulations, by providing an overview of solar physics aspects covering the operation of the solar dynamo responsible for the solar magnetic activity, including the structure of sunspots, the dramatic temperature increase in the solar atmosphere, over quiescent solar filaments to the more dramatic coronal mass ejections that determine our local space weather.