UNIVERSITY OF BIRMINGHAM

Birmingham Environment for Academic Research
www.birmingham.ac.uk/bear

Interacting fields and flows: Magnetic hot Jupiters

Case study

Challenges

Extrasolar planets are planets that orbit around stars other than the Sun. Some of these extra-solar planets are comparable in mass to Jupiter and orbit very close to their host star (much closer than say Mercury in our own solar system) and are consequently very hot (with surface temperatures of 2000K or above). Unsurprisingly these objects are referred to as "Hot Jupiters". These high atmospheric temperatures mean that the planets are losing mass via a planetary outflow. These planets also have magnetic fields and the result is a complex magnetosphere around the planet that tends to fill up with material expelled from the planet.

In addition, the host star will also have a stellar wind (similar to that of our own Sun) and these winds will interact with each other in a complex manner.

Planets in our own solar system are radio emitters, due to the interaction of the solar wind with the planetary magnetosphere (the best example being Jupiter). This radio emission is due to Electron Cyclotron Maser (ECM) emission. A big question is whether we expect the physical plasma conditions to be right in these Hot Jupiters for them to be strong radio emitters. If so, we would expect them to be strong sources and to have been detected already. So far, they have not been and this work seeks to investigate that.

Solution

In order to model these Hot Jupiters and colliding flows we use the PLUTO Magnetohydrodynamic (MHD) code. This code uses Adaptive Mesh Refinement (AMR) to put in extra resolution where it is needed. We set up a model, including both the stellar wind and the outflow from the planet. Both the star and planet will have their own magnetic fields. The result is a very complex interaction, shown in the movie below. We then calculate the physical conditions at each point near the planet (the cyclotron frequency and plasma frequency) to see if the conditions are right for Electron Cyclotron Maser emission.

Results

From a series of calculations, it looks like the conditions for ECM emission are never satisfied for these Hot Jupiters - the outflows from the planet and the confinement within the planetary magnetosphere means that we are unlikely to see ECM emission. While disappointing, this may well explain the lack of detections and will help us refine the range of planetary periods where we might expect to see ECM emission.

Movie Caption

A movie of the interaction between the stellar wind of a Sun-like star and the orbiting Hot Jupiter done on Bluebear (32 cores, running for around 50 days). The complex interactions are clear, with a tail forming behind the planet, which consists of planetary wind material swept up by the solar wind.

Client Profile
Simon Daley-Yates
School of Physics & Astronomy
University of Birmingham
Edgbaston
B15 2TT

Contact Details
sdaley@star.sr.bham.ac.uk

Product Used
PLUTO MHD code
http://plutocode.ph.unito.it/

Funding
Science and Technology Facilities Council (STFC)

Contributors
Dr Ian Stevens
School of Physics & Astronomy

Submitted April 2018