Star-Planet interaction: Hot Jupiter wind accreting onto the stellar surface.

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Introduction

Due to their physical characteristics and proximity to the central star, Hot Jupiters (HJs) are the natural laboratories to study the processes of star planet interaction (SPI). In fact, HJ's atmospheres are heated up by the radiation arising from the star. The heated planetary gas may escape from the gravitational field of the planet (Lammer et al. 2003). Several works suggested that some systems show stellar activity in phase with the planetary rotation period (e.g. Shkolnik et al. 2003, 2005, 2008, Walker et al. 2008, Pillitteri et al. 2010, 2011, 2014,2015). In this work, we use a 3D magnetohydrodynamic model that includes both the planet and the star and both planetary and stellar winds to investigate whether the material evaporating from the planet interacts with the stellar extended corona, and generates observable features.

Model

The model includes both star and planet and their winds. The model also takes into account the planetary (dipole) and stellar (Parker spiral) magnetic fields. The model solves the following equations in spherical coordinates centred at the center of the star:

1. $\partial/\partial t\, \rho + \nabla \cdot \rho v = 0;$
2. $\partial/\partial t\, \rho v + \nabla \cdot (\rho vv - BB + Ip_t) = \rho g;$
3. $\partial/\partial t\, \rho E + \nabla \cdot [(\rho E + p_t)v - B(v \cdot B)] = \rho v \cdot (g);$
4. $\partial/\partial t\, B + \nabla \cdot (vB - Bv) = 0;$

Where ρ is the plasma density, v the velocity, B the magnetic field, $g = g_p + g_s$ the gravity from both star and planet, E the plasma energy and p_t the plasma pressure.

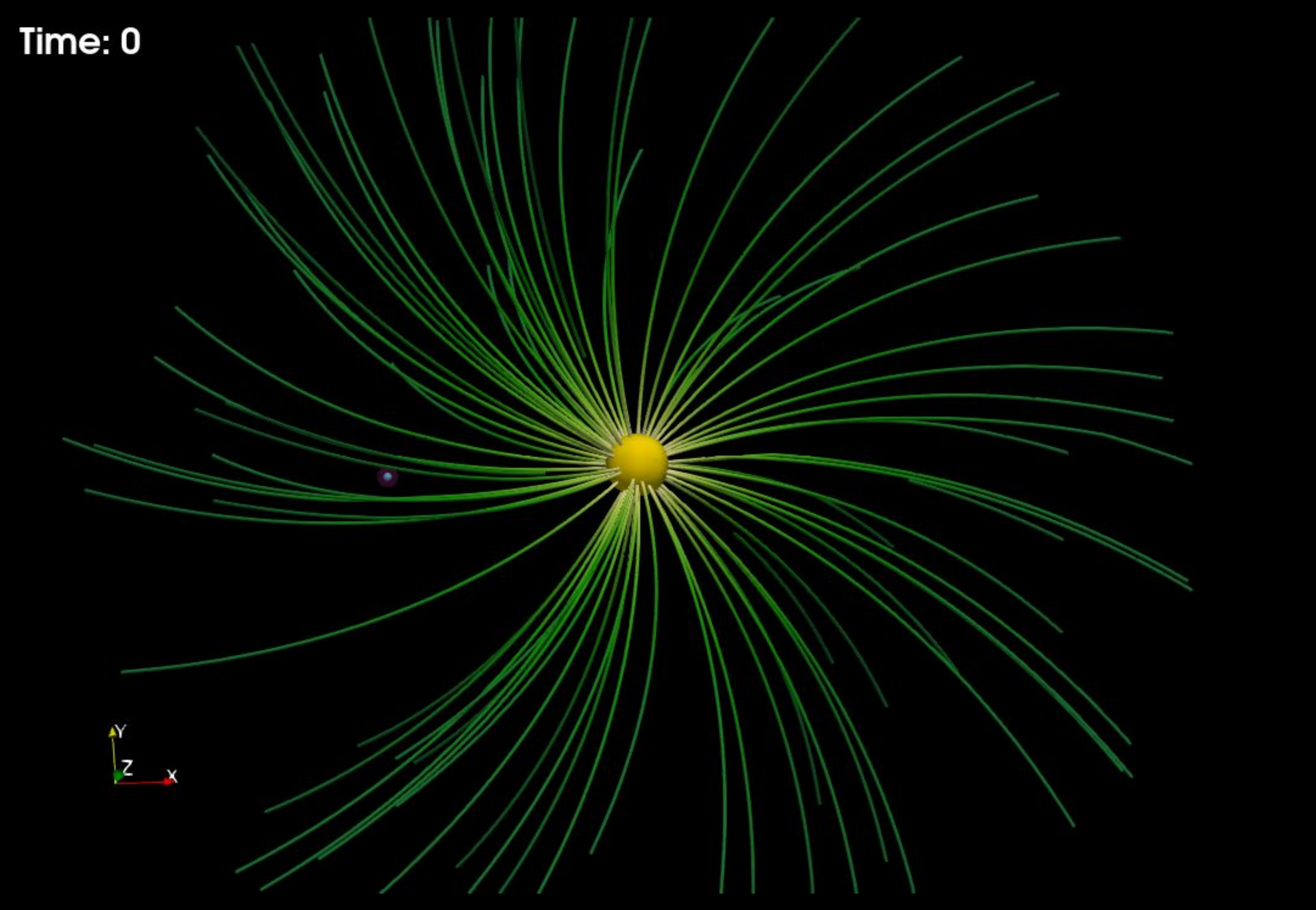


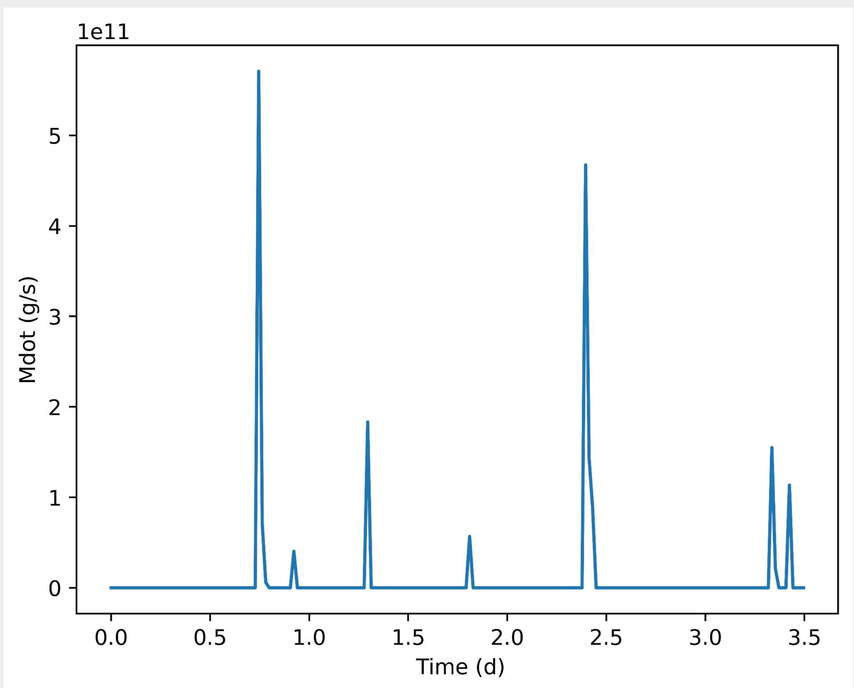
Figure 1. Initial conditions for the simulation. In yellow the central star, in light-blue the planet. The green lines represent the magnetic field lines.

Results

Our preliminary results show that:

- the planetary wind expands and propagates along the planetary orbit (Fig.2).
- During the expansion the wind strongly perturbs the stellar magnetic field (Fig.2).
- Part of the planetary wind collides with the stellar wind and a fraction of the planet's outflow is funneled by the stellar magnetic field and accretes onto the stellar surface (Fig.3).

Figure 3. Accretion rate on the stellar surface vs time.



Where the magnetic field is strongly perturbed by the dense planetary wind phenomena of magnetic reconnection may develop.
The accretion and reconnection events may heat up the material at temperatures of few MK, generating X and UV radiation. These phenomena could manifest as stellar activity in phase with the planetary motion.

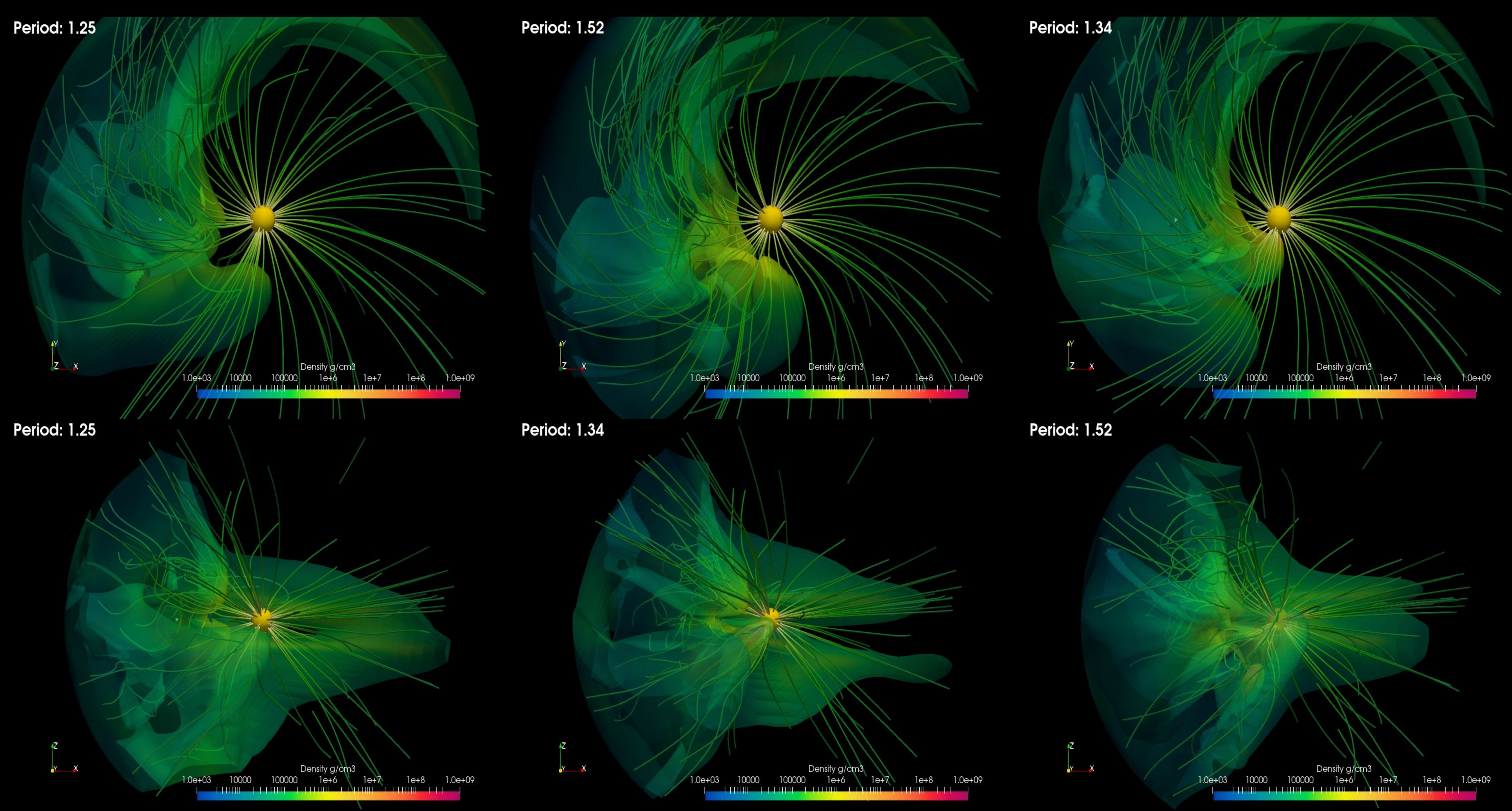


Figure 2. Top panels: pole-on view of the system .Bottom panels: edge-on view of the system. The yellow shere at the center represent the stellar surface, the density of material originated from the planetary wind is shown in blue to red scale. The green lines represent the magnetic field lines.

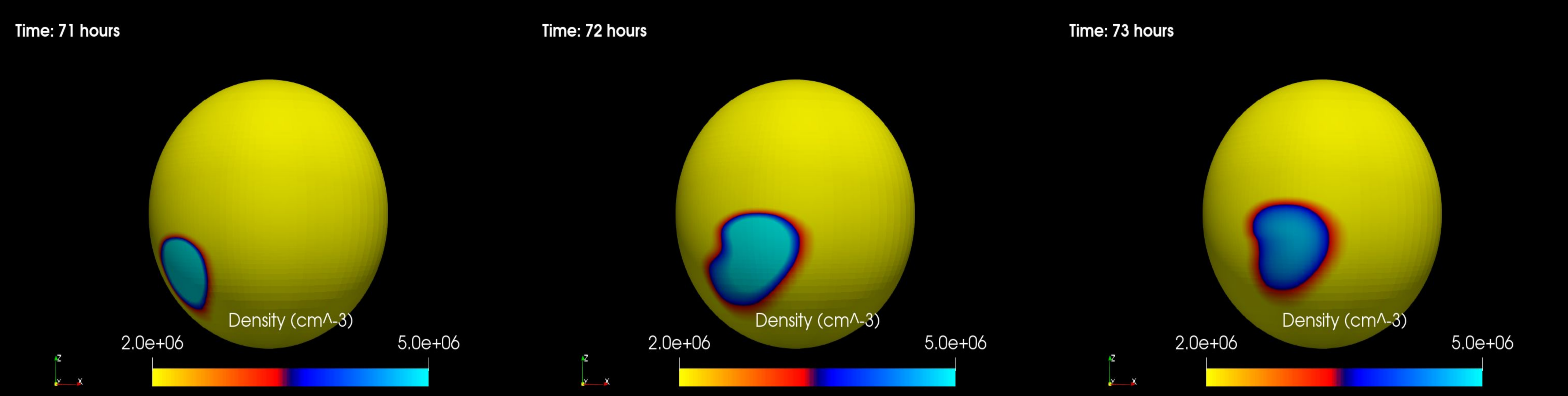


Figure 4. Evolution of accretion spot at the stellar surface due to planetary material. The figures shows edge-on views of the stellar surface (planet is located on the left and is not included in this figure.).

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