

Tidal interactions are distortions that an object feels as a result of gravitational interactions from a nearby companion. We know them from the Earth-Moon-Sun system, where we see them mainly through changes in the sea and ocean levels, which is the cause of changing tides in ports, therefore the name of this phenomenon. The force of gravity is inversely dependent on separation squared. Therefore parts of the Earth closer to the Moon feel a stronger pull than the parts that are further. For tidal interactions to be strong we need a small separation between bodies and a significant mass of the affecting body. Because of this, predictions say that these interactions are present and important in exoplanet systems with hot Jupiters. These are gas giants on incredibly tight orbits, where the orbital separation can be as small as a few stellar radii. Studies of these systems point to tidal interactions as key to understanding their architecture and survival.

In this project, we want to study the efficiency of tidal interactions caused by hot Jupiters on their stellar hosts. These interactions create waves in the stellar interior, which travel to its centre, where, if their amplitude is high enough, they can break the stable stratification, causing a strong dissipation of these waves. As a result of this dissipation, the angular orbital momentum of the planet is transferred to the star, which causes the planet's orbit to shrink and the star to either spin up or heat up at the core. In the star's lifetime, this effect can substantially change the orbit of the hot Jupiter, even causing the planet's destruction. Tidal interactions can also be important for planets on wider orbits when the solar-type star evolves off the main sequence and its radius expands substantially, reducing the distance to these planets.

We can observe the tightening of planet's orbit by a transit timing variation method. A transit occurs when a part of the star's disc is blocked by the orbiting planet, which causes a characteristic drop in brightness. To observe this phenomenon, we need meter-class optical telescopes. We will fit a model to observations with several parameters, one of which is the central time of the transit, derived with high precision, an order of tens of seconds. With enough transit observations gathered over many years we can confirm whether the planet's orbit is tightening and, even without detecting this effect, compare these results with our theoretical predictions. At the moment, there are only two known planets that are inspiralling: WASP-12 and Kepler-1658. This is an insufficient amount to test the theoretical models of tidal interactions properly. Therefore there is a need to find more of these planets.

In this project, we want to expand our previously created and tested methods of predicting tidal interactions. By adding new tidal models, we will be able to recreate the full history of tidal interactions for every studied system. Thanks to the use of innovative numerical solutions, we can create new, more precise predictions for a large number of systems. This will allow us to find new systems with inspiralling planets, which might have been missed in previous predictions done on fewer objects.

After developing these new models, we will make new predictions for all studied systems, yielding us new, full results for each of them. Based on these, we will select the best systems for observational follow-up. The results of this analysis will be made publically available so that any observer can use them.

We will gather new observations for the best systems using the Institute of Astronomy NCU instruments. Additionally, we are cooperating with observers from Spain and Germany, who have access to 1-2 meter telescopes and will provide us with additional observations. We will also use our own archival data, literature data and publically available observations from the TESS space telescope, and we will apply for data to the CHEOPS space telescope. With these data we will be able to perform the transit timing analysis of the systems selected in this project. With these results, we will be able to compare theoretical predictions of tidal interactions with observations and potentially discover new inspiralling planets.