Modelling the origins of white dwarf debris systems

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At least a quarter of all white dwarfs are estimated to be DZs which show evidence for metallic pollution in their photospheres. This pollution could only be present if it had recently been accreted onto the surface from an external source of material which is broadly inline with the composition of the bulk Earth. The canonical theory to explain polluted white dwarfs begins with a planetesimal being perturbed onto an orbit which allows it to cross the Roche limit of the white dwarf. The planetesimal will subsequently undergo tidal disruption and form a ring of dusty and gaseous material which will circularize into the compact debris discs we observe around white dwarfs. However, since 2015 the number of white dwarfs observed with transiting material has increased from one to eight, and each discovery challenges this canonical theory in different ways.

In this talk I will highlight recent theoretical work to model the initial disruptive events which lead to observed circumstellar debris and pollution. I show that an elongated, aspherical planetesimal can chaotically spin itself to destruction outside of the Roche limit through the exchange of spin and orbital angular momentum during pericentre passes. This method of disruption could relax orbital constraints of long-period transiting debris which has so far been assumed to have extremely high eccentricities.

Further, I present an analytical model which can be used to quickly identify what type of planetesimal may produce a particular observation, taking into account a range of possible material compositions and asphericity. This model compares the Roche limit for a particular planetesimal approaching a white dwarf on an extremely eccentric orbit with the size evolution of the planetesimal due to sublimative forces to identify where a tidal disruption event occurs. This model also predicts that white dwarf pollution can occur without the debris disc phase through the direct impact of small pebbles onto the stellar atmosphere.

These theoretical studies may prove useful for the characterisation of currently known, and yet to be discovered, white dwarf debris systems.