The LISA mission: hunting planets in the Milky Way and beyond

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The discovery and study of exoplanets in their diversity is arguably one of the most exciting development in astronomy over the past 25 years, rivalled by the detection of gravitational waves. In this talk I will merge these two fields presenting an original observational method which employs gravitational waves to detect exoplanets. In particular I will show how the Laser Interferometer Space Antenna (LISA) mission will be able to observe Jupiter-like exoplanets orbiting compact white dwarfs binaries emitting gravitational waves at mHz frequencies. This technique will allow us to both overcome the selection bias of current electromagnetic detection techniques, whose observations are limited to the Solar neighbourhood, and to search for post-Main Sequence exoplanets everywhere within the Milky Way and the Magellanic Clouds. This new observational window gave us motivation to deepen our understanding on the final fate of circumbinary systems, for such I will present the theoretical development we tackled on two parallel aspects: (i) the long-term modelling of circumbinary exoplanets, throughout the life of the hosting binary from the main sequence to white dwarf stage; and (ii) the formation of second-generation exoplanets orbiting double white dwarfs. For the first study I will present occurrence rates and physical planetary properties of the theoretical planetary populations we produced with the publicly available TRES population synthesis code, which we developed to account for planetary physics. Our analysis shows that between 23-32% of planets survive the binary evolution to finally orbit a double white dwarf, and that only a small percent of systems get destabilised. For the second study we simulated different planet formation tracks in various second-generation discs around double white dwarfs. These discs, which form as the outcome of the compact binary evolution and the expulsion of the stellar common envelope, can have different temperature, mass and extension. I will show how planetary formation in all these discs around DWDs can be possible. All scientific results presented here are part of an interdisciplinary community effort for the development of the LISA planetary detection science case, before the mission adoption by ESA at the end of 2023.