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Dynamical influence of a wide binary companion on giant planet migration

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About half of the Sun-like stars are part of multiple-star systems. To date more than 100 planets are known moving around one stellar component of a binary star (S-type planets), with diverse eccentricities. These discoveries raise the question of their formation and long-term evolution, since the stellar companion can strongly affect the planet formation process. Here we study the dynamical influence of a wide binary companion on the (Type-II) migration of a single giant planet in the protoplanetary disk. Using a modified version of an N-body integrator adapted for binary star systems and adopting eccentricity and inclination damping formulae (derived from hydrodynamical simulations) to properly model the influence of the disk, we carried out more than 3500 numerical simulations with different initial configurations and study the dynamics of the systems up to 100 Myr. Particular attention is paid to the Lidov-Kozai resonance whose role is determinant for the evolution of the giant planet, although initially embedded in the disk, when the stellar companion is highly inclined. We highlight the high probability for the planet of experiencing, during the disk phase, a scattering event or an ejection due to the presence of the binary companion. We also show that a capture of the migrating planet in the Lidov-Kozai resonance is far from being automatic even when the binary companion is highly inclined, since only 10% of the systems actually end up in the resonance. Nevertheless, using a simplified quadrupolar hamiltonian approach, we point out that, for highly inclined binary companions, the dynamical evolutions are strongly affected by the Lidov-Kozai resonance islands, which create the pile-ups observed around – but not centred on – the pericenter values of 90° and 270° in the final distribution of the giant planets. The influence of the self-gravity of the disk on the previous results is finally discussed.