AN INDEPENDENT CONFIRMATION OF THE FUTURE FLYBY OF GLIESE 710 TO THE SOLAR SYSTEM USING Gaia DR2

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Gliese 710 is a K7V star located 19 pc from the Sun in the constellation of Serpens Cauda (Gray et al. 2006). It has been known for nearly two decades that Gliese 710 is headed straight for the solar system (García-Sánchez et al. 1999; Matese & Lissauer 2002; Bobylev 2010; Feng & Bailer-Jones 2015; Berski & Dybczyński 2016). The most recent published analysis, based on Gaia DR1, concluded that in 1.35 ± 0.05 Myr, Gliese 710 will be 13.366 ± 6250 au from the Sun (Berski & Dybczyński 2016). Here, we present an independent confirmation of this remarkable result using Gaia DR2. Our approach is first validated using as test case that of the closest known stellar flyby, by the binary WISE J072003.20-084651.2 or Scholz’s star (Mamajek et al. 2015).

Gaia DR2 (Gaia Collaboration et al. 2016, 2018) provides, among other data, right ascension and declination, absolute stellar parallax, spectroscopic radial velocity, proper motions in right ascension and declination, and their respective standard errors, all in the solar barycentric reference frame. These data can be transformed into equatorial values as described by e.g. Johnson & Soderblom (1987); state vectors in the ecliptic and mean equinox of reference epoch suitable for solar system numerical integrations can subsequently be computed by applying the usual transformation that involves the obliquity. Using input data from Gaia DR2 and barycentric Cartesian state vectors for the solar system provided by Jet Propulsion Laboratory’s HORIZONS,1 we have carried out N-body simulations as described by de la Fuente Marcos & de la Fuente Marcos (2012). Both input data and integration tools are different from those used in previous works.

For validation purposes, we have used the flyby of Scholz’s star investigated by Mamajek et al. (2015) as test case; this work states that WISE J072003.20-084651.2 may have passed 0.25±0.11 pc from the Sun, 70±15 kyr ago. We have used the same input data (Scholz’s star has no public data in Gaia DR2) and our independent approach to compute the evolution backward in time of 1000 control datasets of this star. Figure 1, top panel, shows our results: the perihelion distance is \( r = 0.28 ± 0.12 \) pc and it happened \( t_r = 73 ± 14 \) kyr ago (averages and standard deviations, the median and interquartile range, IQR, values are 0.25 ± 0.12 pc and 71 ± 16 kyr, respectively), the closest approach might have reached 0.09 pc or 19312 au, 43 kyr ago. Our results are consistent with those in Mamajek et al. (2015).

Applying identical methodology to Gliese 710, but this time using input data from Gaia DR2 (object Gaia DR2 4270814163761488064) and integrations forward in time, we obtain Figure 1, bottom panel: now \( r = 0.052 ± 0.010 \) pc (or 10721 ± 2114 au) and \( t_r = 1.28 ± 0.04 \) Myr into the future (averages and standard deviations, the median and IQR values are 0.052 ± 0.013 pc and 1.28 ± 0.05 Myr, respectively), the closest approach might reach 0.021 pc or 4303 au, in 1.29 Myr (using older input data, we obtain \( r = 0.06 ± 0.02 \) pc and \( t_r = 1.35 ± 0.03 \) Myr).

Our results confirm, within errors, those in Berski & Dybczyński (2016), but suggest a closer, both in terms of distance and time, flyby of Gliese 710 to the solar system. Such an interaction might not significantly affect the region inside 40 au as the gravitational coupling among the known planets against external perturbation can absorb efficiently such a perturbation (Innanen et al. 1997; Tanikawa & Ito 2007), but it may trigger a major comet shower that will affect the inner solar system (see e.g. Mamajek et al. 2015; Berski & Dybczyński 2016; Królikowska & Dybczyński 2017; de la Fuente Marcos et al. 2018).

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1 https://ssd.jpl.nasa.gov/?horizons
Figure 1. Time of closest approach as a function of the distance for the flybys of Scholz’s star (top panel) and Gliese 710 (bottom panel) to the solar system (1000 control datasets each). The bottom panel includes results obtained using input data from Gaia DR2 (red) and older data (green, 100 integrations).
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