Kruger 60 – a plausible home system of the interstellar comet C/2019 Q4

Piotr A. Dybczyński*[1], Małgorzata Królikowska †[2], and Rita Wysoczańska ‡[1]

[1]Astronomical Observatory Institute, Faculty of Physics, A. Mickiewicz University, Słoneczna 36, 60-286 Poznań, Poland

[2]Space Research Centre of the Polish Academy of Sciences, Bartycka 18A, 00-716 Warsaw, Poland

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1 Introduction

An interstellar comet C/2019 Q4 was discovered on August 30 by an amateur astronomer Gennady Borisov at MARGOT observatory (Crimea). One of the obvious questions is where does this object come from. We have at hand an updated list of stars and stellar systems that can potentially act as perturbers on the Oort cloud comets so we decided to check all of them. When searching for a home system of an interstellar body one should look for a past close proximity at a very small relative velocity of order of just few kilometers per second. By means of numerical integration of C/2019 Q4 motion under the influence of the sun, all stars from our list, and the Galactic potential we found that a double star Kruger 60 is a good candidate for a home system of this comet. And the only one from our list.

2 The comet and its orbit

C/2019 Q4 Borisov at the moment of its discovery was 2.99 au from the sun and 3.72 au from the Earth on its inbound leg of trajectory. The comet will pass the perihelion on December 8 this year at a distance of 2.01 au from the sun. At the moment, when we are writing this paper (September 24), 548 total observations are available at the Minor Planet Center[1] covering data-arc from 2019 Aug. 30 to 2019 Sept. 23.

We calculated two slightly different orbits using this data. First orbital solution (a2) is based on selected measurements, the second one (a6) – on selected and weighted measurements; orbital parameters and their uncertainties are given in Table 1. These orbits are used for further dynamical investigations, see Section 4. More details on our methods can be found for example in [5] and references therein. Due to a very short data-arc (24 days) osculating orbit is rather poorly known. At this moment non-gravitational effects are extremely uncertain and they do not improve the quality of the orbital fit to this data-arc.

3 The star

A well known visual binary Kruger 60 is named after Adalbert Krüger who observed it in 1873. Both components are of M spectral type and move in an orbit with a period of 44.6 years and an eccentricity of 0.41. Other designations include BD+56 2783, GJ 860AB, HD 239960, HIP 110893, and ADS 15972. This is a tenth closest multiple stellar system, currently only 4 pc from the sun and approaching.

Very recently both components were observed by Gaia mission spacecraft and the most precise astrometry is available in the Gaia DR2 catalogue [4,objects: Gaia DR2 2007876324466455424 and Gaia DR2 2007876324472098432].

*Corresponding Author: dybol@amu.edu.pl

†mkr@cbk.waw.pl

‡rita.wysoczanska@amu.edu.pl

[1]minorplanetcenter.net/db_search/

Table 1: Heliocentric, purely gravitational, osculating orbits of C/2019 Q4 Borisov based on data-arc from 2019 Aug. 30 to 2019 Sept. 23. Equator and ecliptic of J2000 is used. Solution (a2) is based on unweighted measurements whereas (a6) – on weighted data.

solution	Epoch	T	q[au]	e	ω	Ω	i	RMS[″] /No of res.
a2	20190427	20191208.59015	2.00510	3.34920	209.1527	308.1365	44.0635	0.68/1062
		±0.08598	±.00340	±.01537	±.0760	±.0313	±.0315	
a6	20190427	20191208.54161	2.00699	3.35810	209.1111	308.1545	44.0454	0.47/1075
		±0.05631	±.00223	±.01012	±.0496	±.0205	±.0206	

For the investigation presented in this paper we calculated a center of mass position and velocity using Gaia DR2 positions, proper motions and parallaxes augmented with individual radial velocities found in [2] and using mass estimations of 0.270 $M_\odot$ and 0.180 $M_\odot$ from [1].

4 Past proximity

As the first step we took an orbit obtained by Nakano and published by MPC in CBET 4670 and numerically integrated the motion of C/2019 Q4, the sun and 647 stars or stellar systems from our list of potential stellar perturbers of cometary motion. In a Galactocentric model of motion all mutual interactions were included as well as the overall Galactic potential, see [3] for details of the calculation model, parameters, and methods.

As a result we obtained that 1 Myr ago C/2019 Q4 passed double star Kruger 60 at a small distance of 1.74 pc having an extremely small relative velocity of 3.43 km/s.

To assess the uncertainty of this result we decided to determine our own orbital solution for C/2019 Q4 (see Section 2) which allowed us to generate 5000 clones of this object according to the covariance matrix. These clones were produced from the osculating orbit and then propagated back in time to the distance of 250 au from the sun to obtain a swarm of barycentric, original orbits. We also generated 5000 clones of the double star Kruger 60 with the help of a covariance matrix enclosed in the Gaia DR2 catalogue. Due to the lack of radial velocity uncertainties and some discrepancies in the literature we decided not to vary this parameter at the present stage of this study. Next we integrated all comet clones with the nominal star and all star clones with the nominal comet.

The result of this investigation is shown in Fig.1. In both panels of Fig.1 the influence of stellar data and comet orbit uncertainties on the encounter parameters are presented. We plot distributions of minimal distances between considered bodies and their relative velocities. It can be observed that green histograms which present results of the integration of the star clones with the nominal cometary orbit are much more compact than the magenta histograms showing results of the integration of the clones of the comet and the nominal stellar data. This leads us to the conclusion that, in this case, with data available at moment, our knowledge on the space motion of the star is less uncertain than on the motion of the comet.

To complete this picture we would like to mention, that from our (a2) solution we have obtained a minimal comet – star distance of 2.01 pc at the relative velocity of 3.41 km/s while the solution (a6) gives respectively 1.97 pc and 3.42 km/s. For the comparison we also checked the proximity parameters for the orbital solution presented at JLP[2]. This gives respectively 1.91 pc and 3.44 km/s (Sept. 24). Another comparison with the MPC orbital solution (Sept. 24) gives 1.84 pc and 3.46 km/s.

It should be stressed that the orbit of C/2019 Q4 is still preliminary and the geometry of the past close approach to Kruger 60 might change but the relative velocity of the encounter will remain very small.

5 Conclusions and prospects

We show that the double system Kruger 60 is a plausible source of the interstellar comet C/2019 Q4. As the orbit of this comet will become more precise the minimal distance between these two bodies might vary but their relative

[2] `https://ssd.jpl.nasa.gov/sbdb.cgi`

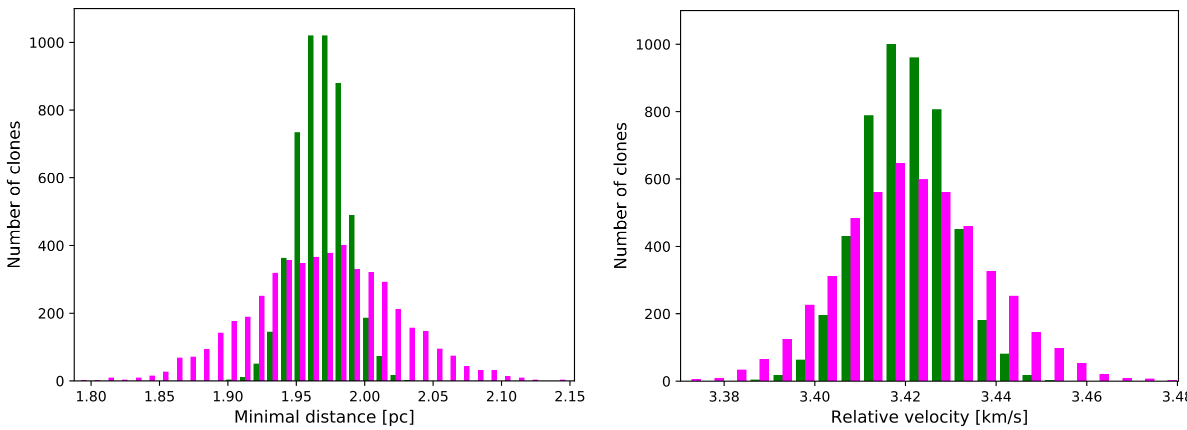

Figure 1: Left panel: the distribution of minimal distances between C/2019 Q4 and the Kruger 60 system. Right panel: the distribution of relative velocities at the time of the closest encounter between C/2019 Q4 and the Kruger 60 system. In both panels green bars indicate close encounters of the clones of the star with the comet in its nominal orbit, whereas magenta bars designate values obtained from examining the clones of the comet motion and the nominal star.

velocity will remain very small, which suggests that C/2019 Q4 might originate from Kruger 60.

To obtain more reliable information we have to wait for longer data-arc of this comet. More precise radial velocities of Kruger 60 components are also necessary.

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