The Non-gravitational Parameters of the Hyperbolic Comet 2I/Borisov

Ireneusz Wlodarczyk[1,2]

1. Polish Astronomical Society, Bartycka 18, 00–716 Warsaw, Poland
2. Polish Society of Amateur Astronomers, Rozdrażew, ul. Powstańców Wlkp. 34, 63–708 Rozdrażew, Poland

We computed the non-gravitational parameters of the comet 2I/Borisov for different astrometric error models. We used all 3092 optical observations from 2018 December 13.47655 to 2020 April 28.447219. The difference between the obtained values of non-gravitational parameters A_1, A_2, and A_3 using different methods of selection and weighting of observations is so small that the orbit is still hyperbolic.

1 Introduction

The comet was discovered on 2019 August 30 by amateur astronomer Genadij Borisov in Crimea at MARGO, Nauchnij, with the help of a partially home-made built telescope with a diameter of 65 cm. The discovered object turned out to be cometary. It has a large eccentricity pointing to a hyperbolic orbit. Therefore according to the JPL Small-Body Database website[1], the comet 2I=C/2019 Q4 (Borisov) belongs to the Hyperbolic Comet, i.e., it is a comet on hyperbolic orbit (eccentricity, e>1.0). It is the second, after 1I/'Oumuamua, interstellar object. The International Astronomical Union named it 2I/Borisov following the naming tradition of honoring discoverers.

2 Orbit of the 2I/Borisov Comet

To compute the orbit of comet 2I/Borisov, we first selected and weighting observations using Bielicki and Sitarski method (Bielicki & Sitarski, 1991). We used the OrbFit v.5.0.7 software[2] with the NASA JPL DE431 ephemerides, and the error model *fcct14* described in Baer et al. (2011) and in Farnocchia et al. (2015). We weight and select observations according to the method from the Near-Earth Objects Dynamic Site.

We also used a new the error model *vfcc17* according to Vereš et al. (2017) where they performed a new statistical analysis of the astrometric errors for the major asteroid surveys. We used the JPL DE431 Solar System model and an additional 17 massive asteroids as described in Del Vigna et al. (2018, 2019) and in Farnocchia et al. (2013a,b).

We computed non-gravitational parameters A_1, A_2 and A_3 with 1-σ uncertainty in the motion of the 2/I comet. A_1 is a non-gravitational radial acceleration parameter, A_2 - non-gravitational transverse acceleration parameter and A_3 - non-gravitational normal acceleration parameter, in au/d^2 units. The initial orbit of the 2I/Borisov comet is presented in Table 1. We used 2550 observations of the

[1] `https://ssd.jpl.nasa.gov/sbdb.cgi#top`
[2] `http://adams.dm.unipi.it/~orbmaint/orbfit/`

2I/Borisov comet and selected 1974 and 2505 observations in *fcct14* and *vftc17* methods, respectively. Table 1. presents initial orbital elements computed for two different error models *fcct14* and *vfcc17*.

Tab. 1: Initial nominal cometary orbital elements of the 2I/Borisov comet for two different error models. Absolute magnitude H, RMS of the orbital fit, and A_1, A_2, A_3 parameters are also given in the following rows. The angles ω, Ω, and i refer to Equinox J2000.0. Epoch: 2020 August 1=JD2459062.5 TDB.

***fcct14* error model**					
q (au)	e	i (deg)	Ω (deg)	ω (deg)	per. time (MJD)
2.00678269	3.3581064	44.054362	308.1524217	209.126433	58825.550347
2.714×10^{-5}	5.513×10^{-4}	1.154×10^{-3}	9.022×10^{-4}	2.235×10^{-3}	3.250×10^{-3}
H=12.652, RMS=0.7703"					
A_1=(-1.3276±1.083)$\times10^{-7}$au d^{-2}					
A_2=(4.3013±1.6664)$\times10^{-7}$au d^{-2}					
A_3=(-1.5970±0.6068)$\times10^{-7}$au d^{-2}					
***vfcc17* error model**					
q (au)	e	i (deg)	Ω (deg)	ω (deg)	per. time (MJD)
2.00683323	3.359502	44.050778	308.149373	209.120103	58825.540533
9.091×10^{-5}	1.474×10^{-3}	2.535×10^{-3}	1.923×10^{-3}	3.872×10^{-3}	5.737×10^{-3}
H=12.652, RMS=0.6324"					
A_1=(1.9395±1.9187)$\times10^{-7}$au d^{-2}					
A_2=(8.7274±4.3710)$\times10^{-7}$au d^{-2}					
A_3=(0.3248±1.2788)$\times10^{-7}$au d^{-2}					

We can see that using the Bielicki and Sitarski method of selection and weighting observations with the NEODys methods and the error models *fcct14* and *vfcc17* implemented in the OrbFit software give precious orbit of 2I/Borisov comet. We also see that the error model *vftc17* gives better results than the *fcct14* because of the smaller number of rejected observations and smaller RMS of fitted orbit. The value of non-gravitational parameters A_1, A_2 and A_3 strongly depend on the error model used.

However, it turns out that the non-gravitational parameters do not change the orbit so much that it remains hyperbolic. The difference between the obtained values of A_1, A_2, and A_3 using the two methods is so small that the orbit is still hyperbolic.

Hence the conclusion that 2I/Borisov comet came to us from outside the Solar System.

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