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PRELIMINARY RESULTS OF STUDY OF COMET C/2020 F3 (NEOWISE)

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This paper presents the results of low-resolution spectral observations of the comet C/2020 F3 (NEOWISE). The emission lines in the spectrum of the comet, observed in the wavelength region $\lambda\lambda 3800-7500$, on July 20 and 27, 2020, were identified using the 2-meter telescope at Shamakhy Astrophysical Observatory. The wavelengths of 90 emission lines, including 31 emission lines from the carbon molecule C_2, 40 from the NH2 molecule, 7 from CN, 4 from C_3, 1 from CH, 2 from the water ions H_2O^+, and 3 unidentified lines were determined. Using approximately 110 visual magnitudes, the comet's absolute magnitude was calculated. The light curve of the comet was analyzed, and specific dynamic characteristics of the comet's orbit were noted.

Key words: emission spectrum – comet – C/2020 F3 – evolution – orbit

1. INTRODUCTION

Introduction Comet C/2020 F3 (NEOWISE), or Comet NEOWISE, is a long-period comet with a near-parabolic orbit. It was discovered on March 27, 2020, by astronomers during the NEOWISE mission of the Wide-field Infrared Survey Explorer (WISE) space telescope. At the time of discovery, it was an 18^{th}-magnitude object, located 2AU from the Sun and 1.7 AU from Earth and was observable with the naked eye. The orbital parameters of the comet are as follows: Epoch 2458953.5 (April 14, 2020); $\mathrm{q} = 0.295; \mathrm{e} = 0.99921; \mathrm{i} = 128.93°; \Omega = 61.01°; \omega = 37.28°$. This paper provides a concise overview of the research conducted at the Shamakhy Astrophysical Observatory on this comet.

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2. SPECTRA OF THE COMET (OBSERVATIONS AND DATA REDUCTION)

The comet's spectra were obtained using the 2-meter telescope at the Shamakhy Astrophysical Observatory on July 20 and 27, 2020. During the observations, the comet was at heliocentric distances of 0.503AU and 0.361AU, respectively. The spectra were captured using the 2-meter telescope equipped with a UAGS + Canon EF objective ($f = 200\,\mathrm{mm}, f/2$) and a CCD Andor (ikonL936-BEX2-DD, 2048x2048 pix, 1 pix=13.5 μm) spectrograph at the Shamakhy Astrophysical Observatory in Azerbaijan [1]. The spectral range covered was $\lambda\lambda 3800 - 7500$. The slit width was 1.1 arcsec, and the height was 50 arcsec, with a spectral resolution of R = 1700. Spectra processing was carried out by using the latest version of the DECH 30 software package [2]. The spectral extraction process included dark current subtraction, flat field corrections, cosmic ray removal, 2D linearization of wavelengths, and subtraction of the standard star spectrum, all performed using an IRAF mask.

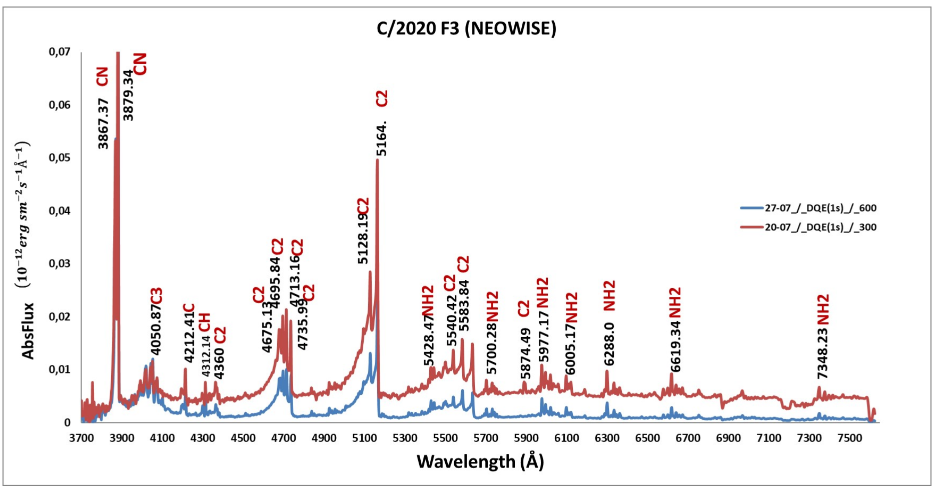

Fig. 1. Spectrum of comet C/2020 F3

3. RESULTS OF OBSERVATIONS

Figure 1 presents the spectra obtained on both nights. The spectra of the comet are displayed in absolute energy units, and corrections for the instrument's response (rectification) were applied based on the spectrum of a standard star. In the comet's spectra, numerous prominent emission features were observed in the range of 3865 Å to 7376 Å. The spectral lines within the comet's spectra have

Table 1. Catalog of emission lines in the spectrum of the comet C/2020 F3

cat	Molecule	cat	Molecule	cat	Molecule	cat	Molecule
3865.38	CN	5163	C2	5963.68	C2	6360	NH2
3867.38	CN	5164.99	C2	5977.17	NH2	6468	NH2
3871.37	CN	5331	C2	5995.02	NH2	6506	NH2
3873.36	CN	5334.13	C2	6005.17	NH2	6534.03	NH2
3879.34	CN	5383.56	NH2	6019.95	NH2	6577	H2O+
4038.43	C3	5398.65	NH2	6020.36	NH2	6599	UNID.
4040.89	C3	5417.02	NH2	6031	C2	6600.16	NH2
4046.4	C3	5428.47	NH2	6034	C2	6617	NH2
4050.87	C3	5443.78	NH2	6055	C2	6619.34	NH2
4195.92	CN	5464	NH2	6059.74	C2	6640.71	NH2
4212.42	CN	5498	C2	6098.23	NH2	6655	NH2
4312.14	CH	5502.92	C2	6108.19	NH2	6659.18	NH2
4360.01	C2	5540.42	C2	6121.13	NH2	6671.76	NH2
4675.13	C2	5583.84	C2	6122.15	C2	6750.58	NH2
4679	C2	5585.49	C2	6186	C2	6754.61	NH2
4695.84	C2	5632	C2	6190.77	C2	6970.88	NH2
4713.16	C2	5700.28	NH2	6274.27	NH2	6982	CN
4734	C2	5703.05	NH2	6288.05	NH2	7070	H2O+
4735.99	C2	5707.04	NH2	6298	UNID.	7348.23	NH2
4924	C2	5752.75	NH2	6320.76	NH2	7376.49	NH2
5093	C2	5867	C2	6332	NH2		
5095.96	C2	5874.49	C2	6334.53	NH2		
5128.19	C2	5925	UNID.	6345.27	NH2		

been identified, and their associations with specific elements and molecules have been determined. Emission lines of CN, CH, C_3, C_2, and NH_2 were observed in the comet's spectrum. The intensities of the strong lines observed at wavelengths 3867.37, 3879.3, 4212.41, 4695.84, 5128.19, 5164.99, and 5583.84 Å are reported, respectively. Table 1 presents the specific results of the spectral processing, including the identified molecules and their corresponding wavelengths. The identification procedure based the catalog referenced as [3].

Visual Photometry of the Comet Based on approximately 110 visual magnitudes published on the International Comet Quarterly website (http://www.icq.eps.harvard.edu), we determined the absolute magnitude of the comet. Using Orlov's formula [4],

$$\mathrm{Hy} = \mathrm{m} + 5\lg\Delta + 2.5\mathrm{nlg},$$

(where n-photometric parameter, Δ and r-geo- and heliocentric distances, accordingly) we obtained the values:

$$\mathrm{Hy} = 7^{\mathrm{m}}.35; \mathrm{n} = 6.22.$$

Similarly, according to Vsekhsvyatsky's formula

$$\mathrm{H}_{10} = \mathrm{m} + 5\lg\Delta + 10\lg,$$

we calculated the value of $\mathrm{H}_{10} = 7^{\mathrm{m}}.71$. We calculated the absolute magnitude of the comet for pre- and post-perihelion periods using both formulas. The comparison of these values suggests that the comet has a slight perihelion asymmetry in its magnitude.

4. DYNAMICAL PROPERTIES OF THE COMET

We have also determined some specific dynamic characteristics of the comet's orbit. The comet's orbit, due to its configuration relative to the orbits of the giant planets, is very stable. Its aphelion distance is approximately 480AU, indicating its origin from the scattered disc.

We calculated the Tisserand's constant of the comet relative to the four giant planets:

$$\mathrm{T_J} = -0.41; \mathrm{T_S} = -0.26; \mathrm{T_U} = -0.14; \mathrm{T_N} = -0.05.$$

These values are significantly different from the optimal value of 3 , suggesting that interactions between the comet and these planets are unlikely. This assumption is further supported by the positions of the comet's orbital nodes relative to the ecliptic, with $\mathrm{R_{near}} = 0.33$ and $\mathrm{R_{dist}} = 2.86$, both far from the orbits of the giant planets.

Additionally, we calculated the comet's Minimum Orbit Intersection Distances (MOID) values relative to the orbits of the nine planets. These values (Mercury-0.014; Venus-0.365; Earth-0.362; Mars-0.315; Jupiter-0.812; Saturn-2.647); Uranus-5.719; and Neptune-11.260 AU) exceed the sizes of the planets' spheres of influences: Consequently, we can assumed that the comet avoids close approaches to the known planets.

We also projected the evolution of the comet's orbit for 30,000 years into the past and future. The numerical calculations were conducted in a heliocentric frame of reference, extending 3×10^4 years into the past, using the Bulirsch-Stoer algorithm within the MERCURY package [5]. Our numerical explorations considered a model of the solar system including the gravitational forces of the Sun and the eight main planets, with initial data sourced from the JPL HORIZONS Ephemeris System DE441.

In the context of the origin of comets, we are particularly interested in the orbit's past evolution. Figure 1 allows for tracking the evolution of the semi-major axis in the past. During this period, the semi-major axis did not change significantly, casting doubt on the comet's origin from the Oort cloud. Instead, the source of the comet may be the scattered disc. However, there are noticeable periodicities in its changes, the reasons for which are currently unknown. These periodicities may be associated with planetary configurations.

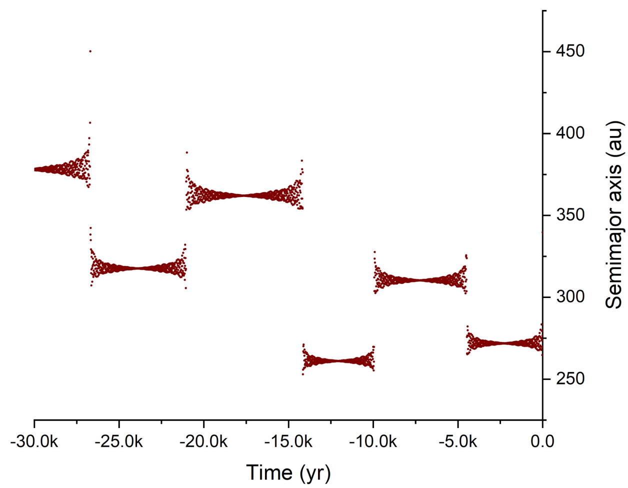

Fig. 2. Evolution of the semimajor axis in the past for the 30 000 years.

5. CONCLUSIONS

• The molecules identified in the comet's atmosphere include CN, CH, C_3, C_2, and NH_2.

• In terms of absolute brightness, the comet holds a middle position among the long-period comets.

• The comet's orbit is highly stable; its favorable trajectory allows it to avoid close encounters with known planets.

• Based on calculations extending back 30,000 years, it is evident that the comet did not originate from the Oort cloud. Throughout this period, the comet's trajectory remained within the boundaries of the scattered disk.

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