# OBSERVATIONS OF ASTEROIDS AND COMETS AT ANDRUSHIVKA OBSERVATORY


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**Introduction**
Andrushivka Observatory (MPC code A50), an advanced amateur observatory in the north of Ukraine, is located precisely at latitude 50° north and longitude 29° east.
The selection of the site place was justified by the limited financing of the project of private observatory.
The climate conditions here are typical of the Eastern Europe, with some 80-100 clear nights in a year suitable for observations. Thanks to the location in a country outside the city, objects down to 20.5m are accessible for observations.

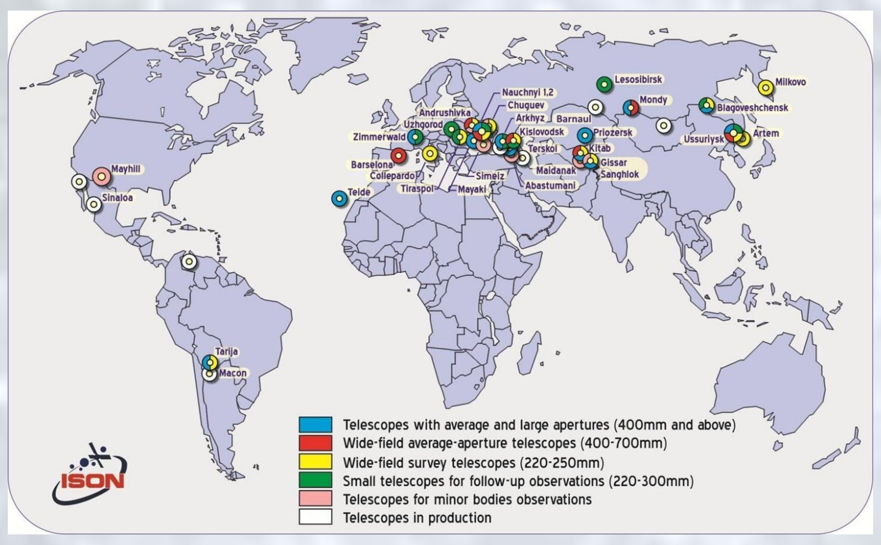
**Equipment**
The principal instrument of the observatory is the Zeiss-600 Cassegrain reflector (D=0.6m) made by Carl Zeiss Yena. It is equipped with a self-contained spectrograph as well as a set of standard UBVR and cometary filters. Zeiss-600 is used for the observations of asteroids and comets. Other two telescopes with the apertures of 0.6m and 0.22m, respectively, are used for the survey of space debris within the framework of the ISON project. Each of the telescopes is equipped with a FLI CCD camera with a 36x36 mm chip.

**Photometry of asteroids**
The observations of the small bodies of the Solar System began in 2002, and they were carried out in several directions. As an occasional member of Photometric Survey for Asynchronous Binary Asteroids (BINAST), the following asteroids were observed to derive the light curves[2]: (3007) Reaves, (4570) Runcorn, (7792) 1995 WZ3, (3951) Zichichi, (16233) 2000 FA12.

**Asteroid survey**
In the course of the asteroid survey program, 130840 positions of 40108 objects (of them 66 comets) were obtained. As stated by the latest DISCSTATUS REPORT, 337 MPC designations have been assigned for A50 with 82 numbered minor planet discoveries.
The NEODYS database records 2510 A50 observations of 376 NEO asteroids [3].
Discoveries outside the MBO: 1 Jovian Trojan, 8 Mars-crossers, and 2 NEOs of Amur type (2007 QA2 and 2008 KB12). The latter has an orbit, typical of Jupiter family comets [4].

**Software**
In 2009 Andrushivka observatory initiated and tested the Software of Automatic Detection of Asteroids and Comets COLITEC [5], which was further developed in the observatory ISON-NM (MPC H15). With its aid the asteroid survey is carried out remotely and observations are processed in the real time.

**Collaboration with ISON**
Since 2008 Andrushivka is a member of the ISON project [10], thanks to which the observatory has been completely equipped by CCD cameras and an optical coma corrector for Zeiss-600 primary mirror. Two other telescopes (0.6m and 0.22m) for space-debris survey were put into operation. In 2009 and 2011 the observatory held two ISON workshops on asteroid observations and COLITEC upgrades.

Comet C/2003 WT42 (LINEAR) was observed at Andrushivka on February 10, 2005 when the dust tail was not developed. These and our other observations of the comet were fitted using the Monte Carlo model to study its dust component (Figs. 7,8) [1].

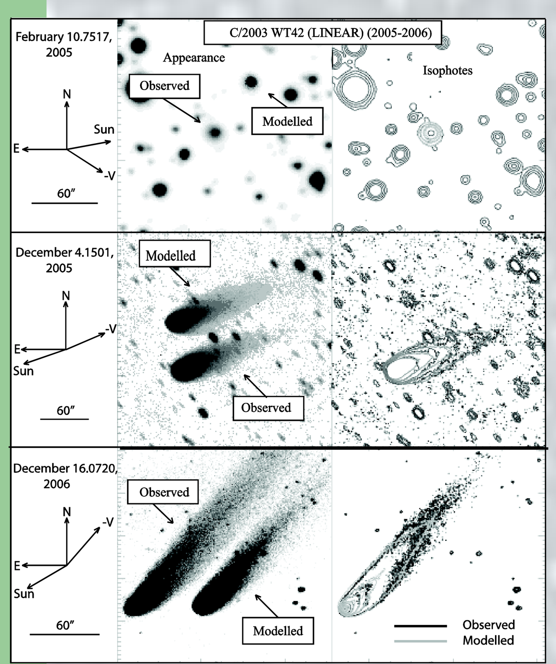


Fig. 7. The tail of comet C/2003 WT42 (LINEAR) observed in 2005 and 2006. The modeled brightness distribution is overlaid the observed images and shifted for clarity (right panel). The left panel illustrates the contour plots of observed and simulated brightness with dark and gray lines respectively. The scale bar of 60″, directions to North, East, and the Sun are marked.

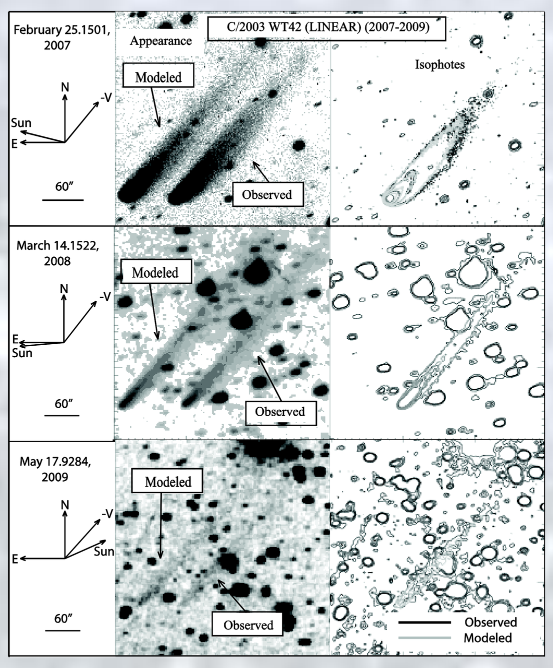


Fig. 8. The same as Fig. 7 for the observations made in 2007, 2008, and 2009.

**Prospects**
At present in association with the ISON, the new wide-angle telescope (D=0.5m) with the field of view of 2x2 deg and the resolution better than 2” is designed for the survey of asteroids. It is planned that the telescope will be installed at a site with favorable atmospheric conditions and remote observations with it will be started in 2013. We also hope to accomplish the long-term automation of Zeiss-600.

**Photometric and spectroscopic observations of selected comets**
Photometric and spectroscopic observations of 9 comets were made at Andrushivka observatory with the 60-cm telescope Zeiss-600 during 2003 – 2006.

***Spectra***
The spectra of bright comets, 2P/Encke, 73P/Schwassmann-Wachmann 3 (fragments B and C), C/2001 Q4 (NEAT), C/2002 T7 (LINEAR), C/2004 Q2 (Machholz), C/2006 M4 (SWAN), were obtained using the spectrograph UAGS installed at the Cassegrain focus of the telescope and a CCD. The spectra cover the optical spectral window from 3600 A to 9200 A with a resolution of 2.0-6.2 A.
We carried out the identification of 256 spectral features in the C/2001 Q4 (NEAT) spectrum [1,6]. We found emissions of CN, C2, C3, CH, NH2, CH+ and H2O+ in our spectrum (Figs. 1,2). The gas production rates for CN, C2, C3, and NH2 were calculated using a Haser model.

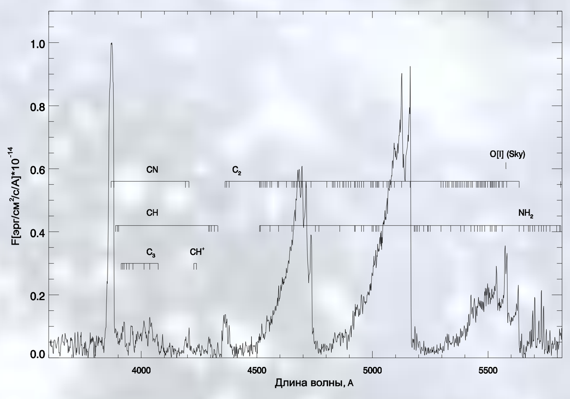


Fig. 1. Blue section of the C/2001 Q4 (NEAT) spectrum.

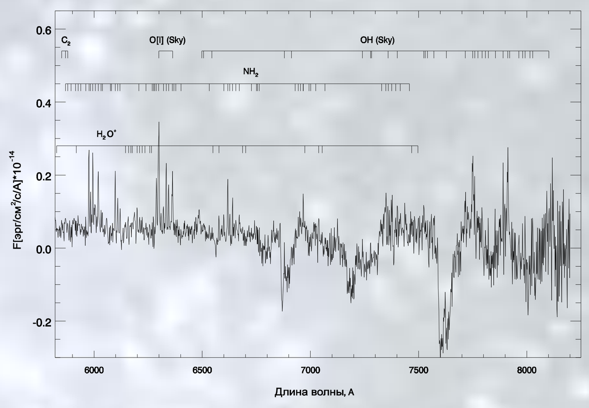


Fig. 2. Red section of the C/2001 Q4 (NEAT) spectrum.

The emissions of the CN, C2, C3, CH, NH2, CH+, and H2O+ molecules were identified in the spectrum of comet C/2004 Q2 (Machholz) (Figs. 3,4).
The spectra of comet C/2002 T7 (LINEAR) were analyzed to derive the normalized gradient of the observed continuum. The calculated value of 7% per 1000A is in agreement with the data for other comets [7].

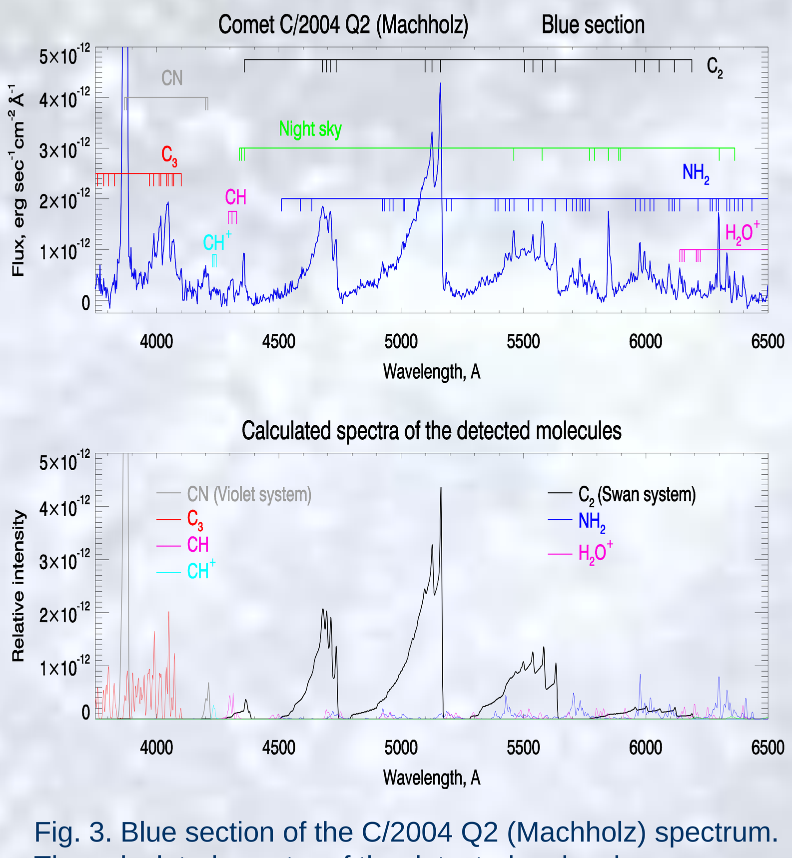


Fig. 3. Blue section of the C/2004 Q2 (Machholz) spectrum. The calculated spectra of the detected molecules are displayed at the bottom.

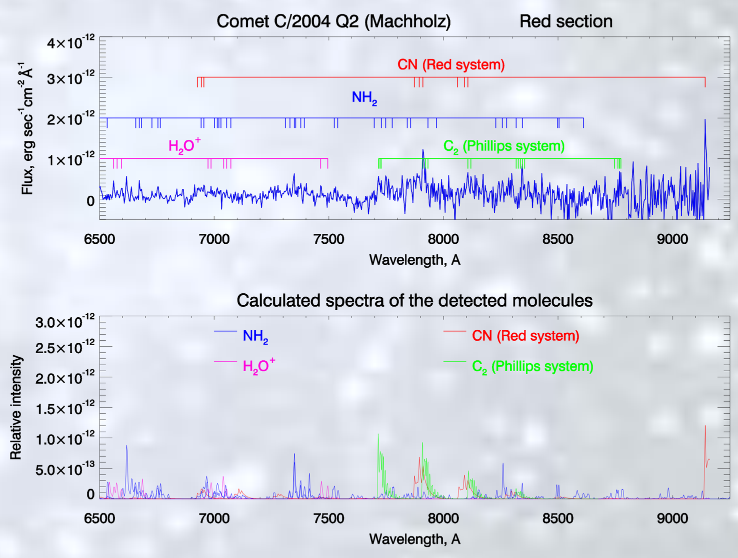


Fig. 4. Red section of the C/2004 Q2 (Machholz) spectrum. The calculated spectra of the detected molecules are displayed at the bottom.

***Photometry***
The photometric observations of a number of the bright comets were made using narrow-band HB filters. An example of such a data obtained for comet C/2004 Q2 (Machholz) is displayed in Fig. 5.

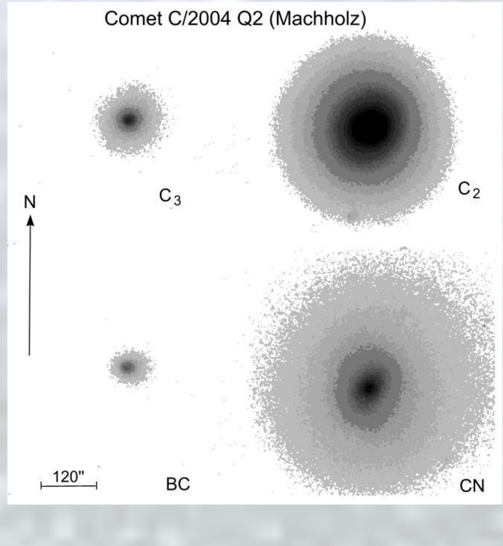


Fig. 5. Distribution of the C2, C3, CN molecules and dust in the head of Comet C/2004 Q2 (Machholz) on February 7, 2005. Cometary interference filters.

***Occultations***
Variations of brightness of stars at occultation by coma of comet 73/P Schwassmann-Wachmann 3 (fragment C) were used for calculation of optical thickness of the cometary coma and albedo of the cometary dust [8].

| $\rho_{min}$, km | $\tau_{max}$ | $Af\rho$, cm | $A_{min}$ |
|---|---|---|---|
| 180 | 0.196 0.059 | 4000 | 0.00057 |
| 700 | 0.195 0.057 | 5000 | 0.00018 |

***Dust in distant comets.***
Three distant comets having perihelia beyond Jupiter’s orbit were observed to study their dust environment. Two of them showed prominent dust tails and were analyzed with a Monte Carlo model to derive the physical characteristics of the dust grains.
The dust tail of comet C/2001 K5 (LINEAR) was fitted by the Monte Carlo model assuming Greenberg’s model of the cometary grains (Fig. 6) [9].

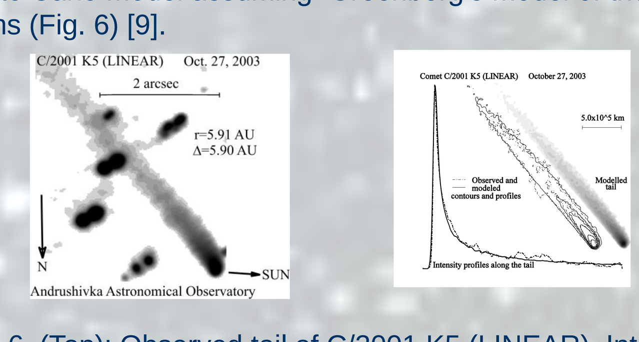


Fig. 6. (Top): Observed tail of C/2001 K5 (LINEAR). Intensity scale is logarithmic.North is down.(Bottom): The tail of C/2001 K5 (LINEAR) fitted under assumption of ‘dirty’ ice grains. Observed and modeled isophotes are displayed in the center of the figure. Appearance of the modeled tail, being in the logarithmic scale, is positioned to the right. Intensity profiles are taken along the tail.

**References**

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