HIGH-PRECISION ASTROMETRY OF NEAs VIA EURONEAR OBSERVATIONS

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Abstract. One of the major objectives of EURONEAR is the high precision astrometry of Near Earth Asteroids in a coordinated network. EURONEAR will create synergies between planetologists for follow-up, precovery, and recovery of Near-Earth Asteroids. Results of observational campaigns together with current activities and future plans will be presented.

Key words: Near-Earth Asteroids – astrometry – network activity.

1. INTRODUCTION

EURONEAR is the acronym of European Near-Earth Asteroid Research. EURONEAR network main objective is the increase synergies for a common work in Europe, between professional and amateur astronomers, against the asteroid impact hazard. The current activities in our network are related to recovery, follow-up, discovery of Near-Earth Asteroids (NEAs).

NEAs are designated as small bodies of the solar system with a perihelion distance $q \leq 1.3$ AU and aphelion distances $Q \geq 0.983$AU (Morbidelli et al. 2002). Among them, Potentially Hazardous Asteroids (PHAs) are designated as NEAs having a minimum orbital intersection distance (MOID) ≤ 0.05 AU (Milani et al. 2002) and the absolute magnitudes $H \leq 22$, which corresponds to objects larger than about 150m, assuming an albedo of 0.13. The catalogue of NEAs contains 6,566 objects[1] and 1,084 objects are PHAs.

[1] Number of NEAs discovered in November, 23, 2009

Rom. Astron. J., Vol. XXX, No.XXX, p. XXXX, Bucharest, XXX

Observations of NEAs/PHAs are obviously for three important reasons:

- once a new NEA is discovered, immediate observations are necessary in order to recover and secure its orbit;
- once a NEA is classified as PHA, follow-up observations are necessary in order to improve its orbit, to be able to predict future close encounters and possible collisions with Earth;
- the studies of physical parameters such as synodic periods, color, albedo, taxonomy and size, are necessary in order to obtain a complete data set of dynamical and physical parameters for quantifying its evolution and risk assessment.

2. FACILITIES, OBSERVATIONS AND NETWORK MANAGEMENT

EURONEAR has been working since May 2006. The implementation of the network is organized around a dynamic EURONEAR website (Figure 1) and a specific list of emails.

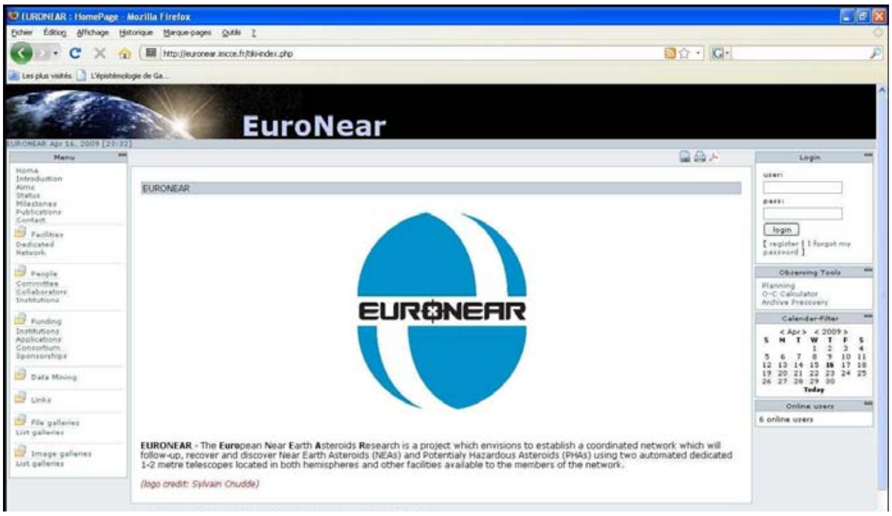

Figure 1 Main page of EURONEAR (http://euronear.imcce.fr). The information concerning the network, milestones, file deposit, schedule of events and astronomic facilities for performing on-line calculations are presented.

Facilities

During the EURONEAR runs, we used a total of nine telescopes located in four countries: France (Pic du Midi 1m and Observatoire de Haute Provence 1.2m), Chile (La Silla 1m, La Silla 2.2m, Cerro Tololo 1m, Las Campanas 1m and Cerro

Armazones 0.84m), Canada (York University 0.6m) and Romania (Vasile Urseanu 0.3m). We used a binning mode 3x3 for the ESO/MPG 2.2m and ESO 1m telescopes due to requirements in minimizing the data transfer and oversampling. The atmospheric conditions were quite heterogeneous between several sites, with the average seeing estimations in the range of 0.8÷4.0″, the lowest value being in La Silla and Las Campanas, while the worst seeing was recorded for Vasile Urseanu observatory in Bucharest, and York University in Toronto.

The images were deflated and debiased before the astrometric measurements. Approximately 80% of the images were reduced using Astrometrica software, and USNO-B1 catalogue. For the rest of images we used some personal procedures (in MIDAS, IDL or IRAF). It is important to note that some of observations were treated with specific software, under development among the EURONEAR members, based on the CPL (http://www.eso.org/sci/data-processing/software/cpl/) procedures and using the UCAC2 catalogue.

Observations

The major part of observations was obtained in visiting mode at several observatories over the world. Partly, these runs were obtained as the result of regular successful applications for observing time. The rest of the nights were observed with the telescopes in Pic du Midi, Cerro Armazones, Admiral ”Vasile Urseanu” in Bucharest, and York University.

The runs obtained via regular applications offer the advantage of having enough time for preparing the run and the *ad hoc* team to work for data reduction. This organization is essential when a huge amount of data is obtained during the run (for example the run with 2.2m MPI/WFI on La Silla). At the opposite, the facility *at disposal* offers the flexibility of schedule, by choosing the period of observations and also specific targets to be studied.

Network management

Preparing the nightly observing lists. While NEAs are objects with fast apparent movement, their period of visibility could change dramatically in just a few days. This is the reason why, in the case of a newly discovered object, the *optimum* window of observations (defined mostly as about 20 days after discovery), could be valorized for recovery and to secure the orbit. In this sense, EURONEAR developped its own scheduler for NEA observations, available for free access on its webserver. Querying in real time the Spaceguard Survey and NEODyS servers, our EURONEAR planning tool classifies the objects which are the most important and favorable to be observed, following several flags, such as the object class (VI, PHA, NEA) and requirement of new observations, orbit uncertainty, proper motion, apparent magnitude, date, local time and zenithal distance. From our experience, we underline the importance of establishing of a target list every few hours before an effective night of observations.

The software and catalogues for data reduction. The choice is made by the necessity to establish a common friendly user interface for data reduction. Within the EURONEAR network, data-reducers could be professional, amateur astronomers and students, thus the common software should be easy to install and use, with minimum requirements for fine tuning to depend on telescope characteristics. In this sense, our main choice was Astrometrica (Raab 2008) which was used to reduce most of the runs treated by network data-reducers. This software was used by means of the USNO-B1 catalogue. In fact we prefer this catalogue versus UCAC2 because the densification of stars in the southern hemisphere is important, thus the astrometric calibration on small fields is always possible.

Training for data reduction: the network of data-reducers is very important, in the case of wide field observations resulting in huge amount of data. In this sense, the coordinated data-reduction activity implies the use of a standard data reduction procedure (e.g., specific configuration file to be used by Astrometrica for each telescope/CCD) and the pre-training of data reduction with a data-set of images obtained with the same equipment. This activity is mandatory especially when the reducer works for the first time with that telescope.

Data transfer and dispatch to data reducers: necessary in two situations: i) if data reduction is performed on another meridian, and ii) if the amount of data is very large, therefore requiring large participation inside the network (e.g., more members to share the same run). For the EURONEAR activities, we used the FTP/SCP protocols to upload the images following every observing night (together with the log file) mostly to the server located at the IMCCE, this way the night run being available for immediate reduction on a daily basis or in near real time.

3. RESULTS

189 NEAs and PHAs, summing more than 1,650 positions were reported from EURONEAR observations during the last three years. Part of these data could be found in the literature (Vaduvescu et al, 2008, Tudorica et al, 2009, Birlan et al, 2009). More than 90% of these observations were measured using USNO-B1 (Monet et al, 2003) catalogue.

Figure 2 presents histograms of NEAs observations obtained between 2006 and 2008, considering observations from telescopes aperture in the 0.3-2.2m size range. A Gaussian fit was performed for these values assuming non-weighting data, in free parameter mode. These data are confined into an interval estimated roughly at 1" of precision. The Gaussian distribution corresponds to 94.97%of correlation and the FWHM is $(0.401 \pm 0.019)''$ in right ascension. The correlation is 97.81% and the FWHM is $(0.431 \pm 0.013)''$ in declination. The maximum of the Gaussian fit is slightly shifted to positive values, $(0.022 \pm 0.008)''$ in right ascension and $(0.042 \pm 0.006)''$ in declination.

More than 23,000 observations are recorded in the MPC database related to the same sample of NEAs presented in Figure 2. EURONEAR data appears to be better confined around zero (about 0.4″) than are the (o-c) values from the other surveys (of about 0.6″).

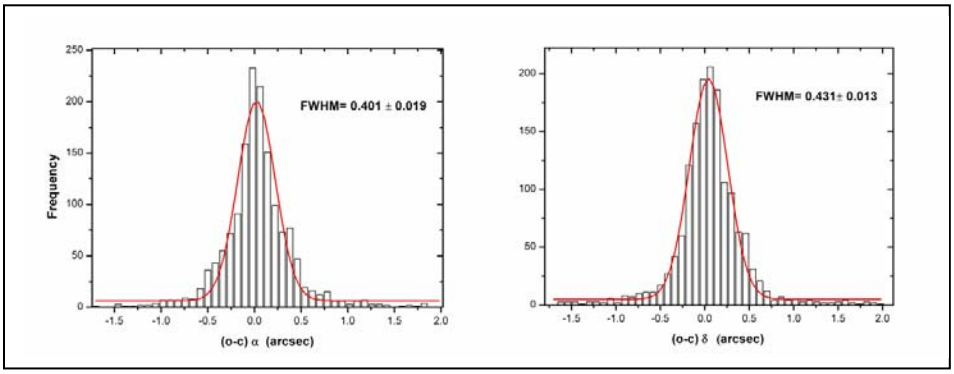

Figure 2. The histogram of (o-c) in right ascension and declination which includes NEOs astrometry obtained between 2006 and 2008 in the frame of EURONEAR (Birlan et al, 2009).

EURONEAR astrometry was already reported and used in the calculation of new osculating elements of NEAs by orbit adjustment techniques. These data contributed not only to diminish the sky uncertainties (Boattini et al, 2007), but also in other strategies of recovery of NEAs by cumulating data over a long period of time (Bowell et al, 1989).

4. CONCLUSION

Astrometry of NEAs remains an important domain in the particular field of astrometry of solar system bodies. EURONEAR data are confined into 1” of precision, with an accuracy of 0.4”, comparable to the internal error USNO-B1, the catalogue of stars used for data reduction. Increasing the precision of NEAs astrometry requires the access to facilities with 2m of aperture and the use of stellar catalogues with small internal errors.

Acknowledgments. The article is based on observations acquired in Pic du Midi, Haute Provence, La Silla, Cerro Tololo, Las Campanas, Cerro Armazones, Bucharest Urseanu, and York University Observatories. The EURONEAR website is hosted by the Institut de Mécanique Céleste et de Calcul des Ephémérides, Observatoire de Paris, France.

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Received on 29 November 2009