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More than 160 near Earth asteroids observed in the EURONEAR network⋆,⋆⋆

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ABSTRACT

Context. The EUROpean Near Earth Asteroid Research (EURONEAR) is a network which envisions to bring some European contributions into the general context traced by the Spaceguard Foundation which was carried out during the last 15 years mainly by the US with some modest European and amateur contributions.

Aims. The number of known near Earth asteroids (NEAs) and potentially hazardous asteroids (PHAs) has increased tremendously, mainly thanks to five major surveys all focused on the discovery of new bodies. But also other facilities are required to follow-up and improvement the orbital parameters and to study the physical properties of the known bodies. These goals are better achieved by a co-ordinated network such as EURONEAR.

Methods. Astrometry is mandatory in order to acquire the positional information necessary to define and improve orbits of NEAs and PHAs and to study their trajectories through the solar system, especially in the vicinity of Earth. Photometry is required to derive some physical information about NEAs and PHAs. In order to achieve these objectives, the main method of research of the EURONEAR is the follow-up programme of objects selected by a few criteria, carried out mostly at 1 m-class telescopes endowed with medium and large field cameras.

Results. 162 NEAs summing more than 1500 individual positions were observed for a total time of 55 nights in both visiting mode and regular runs using nine telescopes located in four countries. The observations were reduced promptly and reported to the Minor Planet Centre (MPC) which validated and included them in the MPC and NEODyS databases following the improvement of their orbital elements. For one binary NEA we acquired photometry and were able to determine its orbital and rotational periods. Complementary to the follow-up work, as many as 500 unknown moving objects consistent with new Main Belt asteroids and one possible NEA were discovered in the analyzed fields.

Conclusions. Our positions present 1″ precision with an accuracy of 0.2–0.4″, sufficient for achieving our immediate main goals. The observations and data reduction were conducted by our network members, which included some students and amateurs supervised by professional astronomers. In most cases, we increased the observational arcs decreasing the uncertainties in the orbits, while in some cases the new positions allowed us to recover some bodies endangered to be lost, defining their orbits.

Key words. astrometry – minor planets, asteroids: general

⋆ Based on observations acquired in Pic du Midi, Haute Provence, La Silla, Cerro Tololo, Las Campanas, Cerro Armazones, Bucharest Urseanu, and York University Observatories.

⋆⋆ Astrometric and photometric data are only available in electronic form at the CDS via anonymous ftp to `cdsarc.u-strasbg.fr` (130.79.128.5) or via `http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/511/A40`

1. Introduction

Near Earth asteroids (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). Potentially hazardous asteroids (PHAs) are designated as NEAs having a minimum orbital intersection distance ($MOID$) $\leq$ 0.05 AU (Bowell & Muinonen 1994; Milani et al. 2002) and the absolute magnitudes $H \leq 22$, which corresponds to objects larger than about 150 m, assuming an albedo of 13%. Among the PHAs we can distinguish the virtual impactors (VIs), objects for which the estimation of impact probability[1] with the Earth is non-zero (Milani et al. 2000a,b).

The interest in the study of NEAs increased tremendously during the last two decades, as the consciousness of the potential danger of these objects for the human society has been raised. Following Milani et al. (2002), the importance of knowledge about NEAs population for the human society was marked in 1990 by the US Congress. NASA was charged with the organization of a strategy "to study ways of increasing the discovery rate of these objects as well as to study the technologies and options for deflecting or destroying an NEO[2], should it be found to pose a danger to life on Earth". The first report on this subject (Morrison 1992) proposed an international NEO survey programme called Spaceguard.

In the last decade we assisted to a complete a list of large sized NEAs/PHAs ($D > 1$ km). This situation is due mainly to five NEAs discovery programs in progress, mostly carried out in the USA: Catalina Sky Survey[3] (Larson et al. 1999; Stokes et al. 2002), LINEAR (Viggh et al. 1998), Spacewatch (Gehrels & Jedicke 1996), LONEOS (Howell et al. 1996), and NEAT (Helin et al. 1997).

In the mean time, the interest in NEAs could be noticed in a few observatories[4] across Europe, and we introduce three of them here.

Klet' Observatory programme in the Czech Republic has been focused on the follow-up tasl using a 0.57 m telescope equipped with CCD cameras (Tichá et al. 2000). About 600 NEAs, summing more than 6500 individual positions were reported between 1994 and 1999. Based on this experience, their new KLENOT programme, using a 1.06 m telescope (Tichá et al. 2002) is currently working and reports follow-up astrometry for about 2700 NEAs observed between 1998 and 2008 and three NEA discoveries.

Another important program we used for this was CINEOS (Bernardi et al. 2002). This program started regular observations on NEAs in 2001, using the 0.60/0.90 m Schmidt telescope of Campo Imperatore Observatory, Italy. The CINEOS survey was designed to discover new objects, joining the main goal of Spaceguard, namely to discover more than 90% of kilometer-sized NEOs by the end of 2008. Between 2001 and 2005, this program reported 30 000 astrometric positions and was credited with the discovery of seven NEAs (Boattini et al. 2007).

The most prolific NEA discovery program in Europe appears to be carried out at the Crni Vrh observatory in Slovenia, and is actually run by a team of amateur and professional astronomers[5]. Equipped with a robotic 60-cm telescope controlled over the internet since 2004, this program leads the European contributions with 13 NEA discoveries (J. Skvarc 2009, private communication).

Astrometry of NEAs is also performed in Russia (Devyatkin et al. 2007), and jointly in Turkey and the Ukraine (Ivantsov et al. 2008), but their programs are not formalized with specific names.

The International Astronomical Union sponsored data centers[6] which are open to all observational reports over the world. These reports are to follow rigorous steps for the validation of the acquired astrometric data (newly discovered or not) before being used in the calculus of orbital elements. New rules are also proposed for increasing the standard procedure (Milani et al. 2007).

It is important to explain the fundamental difference between a program dedicated to the discovery of NEAs and and the one devoted to the follow-up, securement and improvement of orbital elements. In a general sense, the requirement of a survey is to scan a large part of the sky during the entire observing night and discover as many NEAs as possible. Nevertheless, most of the survey programs use instruments with large pixel sizes, sometimes up to 3″, which is inappropriate for accurate astrometry. Alternatively, a follow-up and recovery program focuses on accurate astrometric observations of selected objects announced in the alerts and observing lists maintained by dedicated authorities (such are MPC, Spaceguard Center, JPL, etc.). The requirements of such a follow-up and recovery program are shifted to observations of relatively small fields (10÷30′) and an instrument with a small pixel size (0.3÷1.0″/pixel).

Follow-up observations of NEAs/PHAs are necessary for several important reasons; namely i) once a new NEA is discovered, immediate observations are necessary to recover and secure the knowledge of its orbit; ii) once a PHA is determined, follow-up observations are necessary in order to improve its orbit, to be able to predict future close encounters and possible collisions with Earth; iii) studies of its physical parameters such as rotation periods, color, albedo, taxonomy and size are necessary to extract information about the most possible encounters.

The EURONEAR project envisions to establish a co-ordinated network which will follow-up and recover NEAs/PHAs using 1–2 m-class telescopes (dedicated and non-dedicated) located in Europe and elsewhere (Vaduvescu et al. 2008). While the programs CINEOS, KLENOT, and Crni Vrh are mainly focused on using specific telescopes in Europe to perform observations, the major objective of EURONEAR has been the high precision astrometry of NEAs in a co-ordinated network and the creation of synergies between European planetologists (and not only) for follow-up, precovery, and recovery of NEAs and PHAs.

EURONEAR has been working since May 2006. Besides its main scientific interest, the EURONEAR network is organized in order to increase the collaboration, mostly European, between professional astronomers, amateurs and students interested in NEAs. The implementation of the network is organized around a dynamic EURONEAR website and a specific list of emails.

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[1] Milani et al. (2000b) underline the difference between the *possibility* of an impact with the Earth from the calculus of the *probability* of impact.

[2] Near Earth Object.

[3] Acronym CSS in the article.

[4] In our knowledge there is no exhaustive statistics at this moment in the World (in general, and in Europe in particular) for NEAs activities.

[5] `http://www.observatorij.org/`

[6] AstDys, MPC.

Table 1. Telescopes and detectors used for follow-up, recovery and secure orbits of NEAs.

Telescope	Aperture (m)	CCD	Pixels	FOV (arcmin)	Scale (″/pixel)
Pic du Midi	1.05	THX7863	384 × 288	5.2 × 3.9	0.820
Haute Provence	1.20	TK1024	1024 × 1024	11.7 × 11.7	0.685
Cerro Armazones	0.85	SBIG ST-10	2184 × 1472	15.6 × 8.3	0.430
Cerro Tololo	1.0	Y4KCam	4096 × 4096	20 × 20	0.289
Las Campanas	1.02	SIT#3	2048 × 3650	15.1 × 26.5	0.435
La Silla	1.00	SBIG ST-10	2184 × 1472	3.3 × 2.2	0.090
La Silla	2.20	WFI mosaic	8 × (2184 × 1472)	34 × 33	0.238
Vasile Urseanu, Bucharest	0.30	TC273-home made	640 × 500	21.6 × 16.9	2.30
York University	0.60	SBIG ST-9	512 × 512	4.3 × 4.3	0.505

Notes. The observatory is given in the first column and the aperture in the second one. The CCD camera (third column), the pixel size (fourth column), the field of view (FOV), and the scale (in ″/pixel) are also presented.

2. Observations and astrometry

2.1. Observations

A total of 55 nights of observations are reported in this article. Most of the observations were obtained in visiting mode at several observatories across the world. These runs were partly obtained as the result of regular semestrial applications for observing time. The proposals submitted were successful, and we observed in this mode for a total time of 22 nights. 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 2.2 m MPI/WFI on La Silla). On the other hand, the facilities at disposal offer more flexibility of schedule, allowing among other things for the assessment of specific newly released targets which may need urgent observation. We used a total of nine telescopes located in four countries: France, Chile, Canada and Romania. These facilities are presented in Table 1.

NEAs are objects with fast apparent movement, with a period of visibility which can change dramatically in just a few days. For that, EURONEAR has developed its own scheduler program for NEA observations, available on its webserver[7]. For newly discovered objects, the optimum window of observations is defined for each asteroid according to a few factors, so as to ensure maximum probability of successful follow-up and consequently securing of their orbits. Typically, windows of about 20 days after discovery suffice in such cases. This scheduling tool is at the disposal of the scientific community.

We used a binning mode of 3 × 3 for the ESO/MPG 2.2 m and ESO 1 m 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 $0.8 \div 4.0''$, the lowest value being in La Silla and Las Campanas, while the worst seeing was recorded for the Vasile Urseanu observatory in Bucharest, and York University in Toronto.

2.2. Astrometry

The images were calibrated by flat field and bias frames before the astrometric measurements. Approximately 80% of the images were reduced using the Astrometrica software[8] and the USNO-B1 catalog. Astrometrica is easily accessible and very often used by the amateur community for asteroid observations, and we decided to use it mainly because most of our data reduction was made by students and amateurs, members of our network. Despite its relatively low astrometric precision and lack of proper motion of sources, we preferred the USNO-B1 versus UCAC2 catalog because of the higher density of stars of USNO-B1 and its all-sky coverage, thus the astrometric calibration of small fields is always possible.

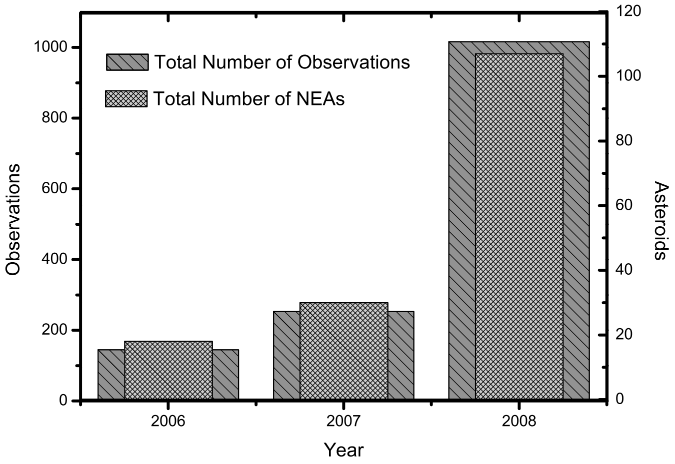

Fig. 1. The 1538 positions of a total of 162 NEAs observed in the EURONEAR network, in cumulative number per year, between 2006 and 2008.

For the rest of the images we used some personal procedures in MIDAS, IDL or IRAF. It is important to note that some of the observations were treated with a specific software[9] which is under development among the EURONEAR members, based on the CPL[10] procedures and using the UCAC2 catalog.

162 NEAs, summing more than 1500 individual positions were observed in the visiting mode in the frame of the EURONEAR network, between May 2006 and Dec 2008, as presented in Fig. 1. The observing log table is presented in the Appendix of this article and includes the telescope location, the name of the asteroid, the type, the date of observations,

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[7] http://euronear.imcce.fr

[8] Raab, H. 2008, http://www.astrometrica.at

[9] The embryo of a future pipeline to be used by our network.

[10] http://www.eso.org/sci/data-processing/software/cpl/

Table 2. An example of the catalog EURONEAR_Release1.

Asteroid	Date UT	Right ascension (h m s)	Declination (° ′ ″)	Mag	Filter	Obs code
162173	2008 03 12.02639	06 29 35.020	–13 58 02.20	18.2	*R*	809
162173	2008 03 12.02795	06 29 35.540	–13 58 01.10	18.1	*R*	809
162173	2008 03 12.02970	06 29 36.110	–13 58 00.00	18.1	*R*	809
162173	2008 03 12.03134	06 29 36.670	–13 57 58.90	18.1	*R*	809
162173	2008 03 12.03314	06 29 37.270	–13 57 57.70	18.1	*R*	809
162173	2008 03 12.03509	06 29 37.930	–13 57 56.40	18.2	*R*	809
162173	2008 03 12.03672	06 29 38.460	–13 57 55.40	18.0	*R*	809
162173	2008 03 13.03905	06 35 29.610	–13 46 54.10	17.9	*R*	809
162173	2008 03 13.04053	06 35 30.110	–13 46 53.10	17.9	*R*	809
162173	2008 03 13.04209	06 35 30.620	–13 46 52.00	17.8	*R*	809
162173	2008 03 13.04562	06 35 31.790	–13 46 49.50	17.9	*R*	809
162173	2008 03 13.04877	06 35 32.850	–13 46 47.40	17.8	*R*	809
162173	2008 03 13.05032	06 35 33.350	–13 46 46.30	17.9	*R*	809
162173	2008 03 13.05196	06 35 33.890	–13 46 45.20	17.9	*R*	809
162173	2008 03 13.05358	06 35 34.430	–13 46 44.00	17.9	*R*	809

Notes. Asteroid number (or its provisory designation), date, right ascension, declination, magnitude, filter, and observatory code are presented.

the apparent magnitude, the exposure time, and the number of observations. This table contains also the apparent motion of the asteroid and the time period (d-days, y-years) between its discovery and the EURONEAR observation.

Most of the runs were conducted using sidereal tracking. However, for a few runs (Pic du Midi and ESO/MPG) we tracked using the half-value of the proper motion of the observed asteroids, which has the advantage to have shorter trails for the asteroids while increasing the exposure time in order to reach fainter magnitudes.

To reduce the ESO/WFI images, a specific procedure was developed. Following the flat and bias treatement of the images, we sliced the mosaic image in the eight CCD components which were treated independently, and we measured them separately. To take advantage of the large field of the ESO/MPG, LCO/Swope and CTIO 1 m runs, we inspected the entire field of these runs besides the observed NEA and reported all asteroids (known and new) found in the images.

Depending on the field of the telescope and the density of the stars in the field, the scale and the orientation of the field were computed using about 6 to 100 catalog stars with a precision better than $0.3''$. The measured (x, y) values were related to the standard (X, Y) coordinates using a linear model. Typically, the differences between the measurements and the catalog positions do not exceeded 300 mas.

The center (x, y) of the measured sources was obtained using a 2D-symetric Gaussian function. The rms fit of the center was lower than 150 mas, depending on the telescope aperture, the magnitude, the seeing, and the method of guiding during the acquision of the image.

3. Results

The catalog EURONEAR_Release1 contains all the data referred into the article. The columns of the release are: the name of the asteroid, rigth ascension and declination for the J2000.0 epoch, magnitude and filter (when available) and the UAI observatory code. A sample of the release is presented in Table 2.

References of reported EURONEAR astrometry are in the following Minor Planets (Electronic) Circulars: Pozo et al. (2008); Scotti et al. (2008a,b); Cavadore et al. (2008); Kern et al. (2008); Elst et al. (2008c); Buie et al. (2008); Vaduvescu & Tudorica (2008); Tubbiolo et al. (2008); Young et al. (2008); Elst et al. (2008a,b); Tholen et al. (2008b); Sheppard et al. (2008); Vaduvescu et al. (2007a,d,b,c); Cavadore et al. (2006).

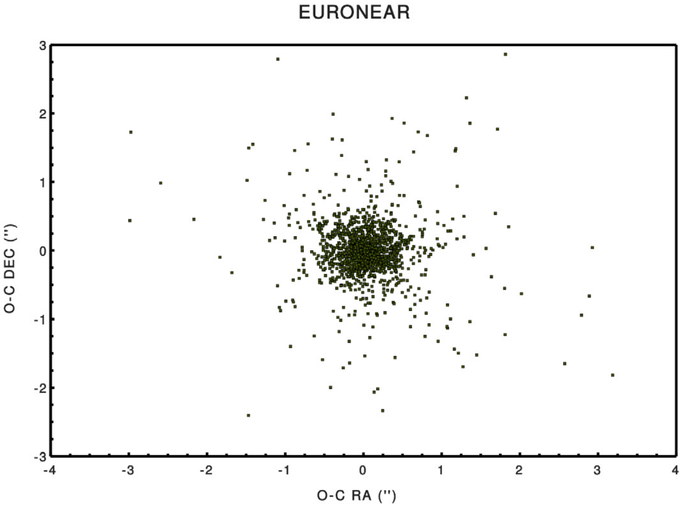

Fig. 2. (o-c) residuals for 1538 positions of 162 NEAs observed in the EURONEAR network. Most of the points are confined within 1″, probing the observational capabilities for all facilities and the accurate data reduction.

All astrometric measurements were accepted by MPC, being included successfully in the procedure of adjustment of the orbital catalogs maintained by JPL and NEODyS. Figure 2 presents the distribution of observed minus calculated (o-c) positions in right ascension and declination for all runs. The values are mostly confined within 1″ for all observatories, probing the precision of data reduction, observational capabilities and the available instrumentation. The frequencies of values (Fig. 4) are centered relatively close to zero.

The individual plots of the (o-c) values for each telescope are available in the Appendix of this paper. The dispersion of observations between observatories is different and is related to the telescope aperture, pixel size and seeing conditions. We will focus our interest on the telescopes for which the (o-c) values are well confined around the zero value.

The Gaussian fit was performed for all (o-c) values in right ascension and in declination, assuming non-weighting data, in free parameter mode. In the right ascension, the Gaussian distribution corresponds to 94.97% of the correlation and the $FWHM$ is $(0.401 \pm 0.019)''$, while for the declination the correlation in 97.81% and the $FWHM$ is $(0.431 \pm 0.013)''$. The

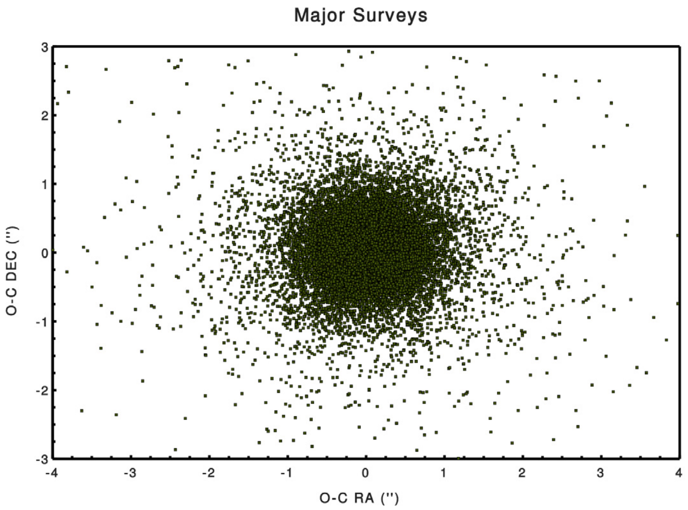

Fig. 3. Over 23 000 (o-c) residuals related with observations performed by all other surveys which observed in the past the same asteroids with EURONEAR. Comparing this plot with the one of Fig. 2, one can observe that EURONEAR observations appear better confined around zero, and this fact is also supported by statistics.

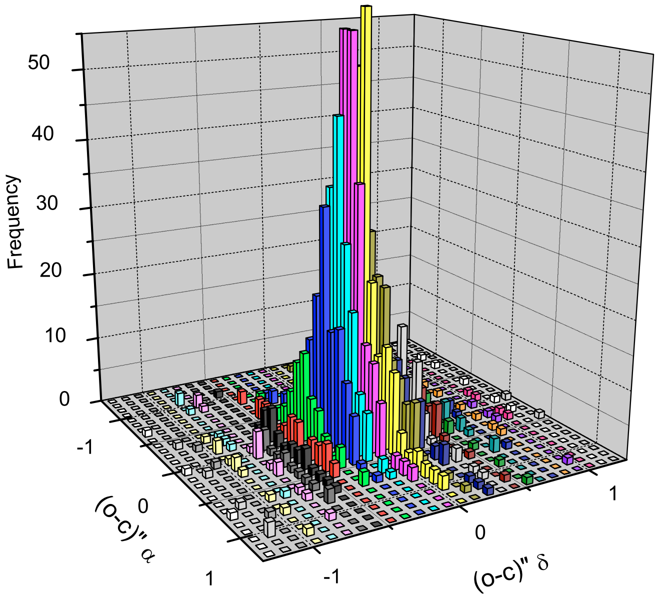

Fig. 4. The frequency of (o-c) values in the plane of right ascension and declination, with a bin value of 0.095″. The values of frequency are centered to the zero value.

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.

The (o-c) values are very well centered around zero for the observations obtained with the 2.2 m telescope. The best Gaussian function is obtained for a $FWHM = (0.218 \pm 0.012)''$ centered at $(0.020 \pm 0.005)''$ in right ascension, and $FWHM = (0.261 \pm 0.037)''$, centered at $(0.023 \pm 0.015)''$ in declination. These values show a very good consistency between the internal errors of the data and the expected position errors from the USNO-B1 reference catalog. Careful analysis of the data shows that the (o-c) values are widely spread for newly discovered objects whose orbit uncertainties were larger, while for the objects observed at two (or more) oppositions the (o-c) values are well confined around zero. This could be seen in Fig. 5.

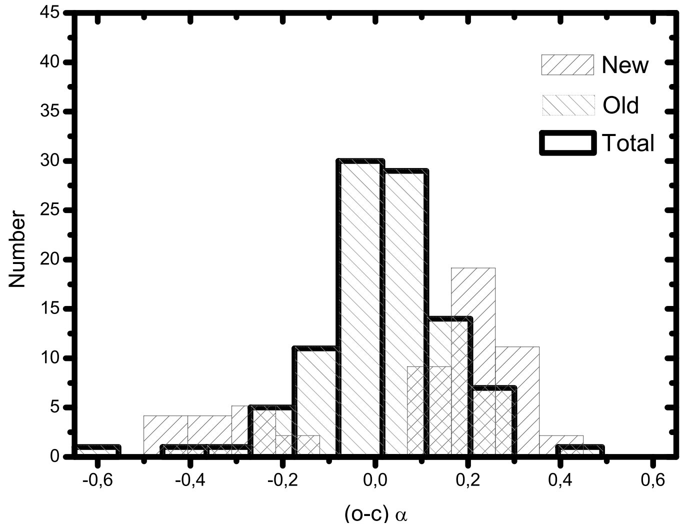

Fig. 5. (o-c) residuals in right ascension for the asteroids observed with 2.2 m telescope, La Silla. These values are widely spread for newly discovered objects whose orbit uncertainties were larger, while for the objects observed at two (or more) oppositions the values are well confined around zero.

Recently, Tholen et al. (2008a) described systematic offsets in the astrometry of (99942) Apophis for more than 200 individual observations. This large offset of approximately 0.2″ *to the north of ephemerides position* was associated to the systematic errors in declination of the star catalog[11], compared to the ICRF sources. From our global histograms of observed objects we cannot confirm such a kind of offset, which suggests that the 0.2″ error is related to a local systematic error in the catalog. Also, such a kind of analysis for a given asteroid of our sample is not possible, while for each object the number of individual observations is around ten (thus statistically irrelevant) and over a short arc of orbit.

We compared our work with other programs, mostly the five major US surveys capable to regularly observe NEAs using facilities similar to those used by our network. In Fig. 3 we plot (o-c)s derived from data taken by all other surveys for the same NEAs which were observed by us. Over 23 000 (o-c) points of Fig. 3 refer to the same observed objects plotted in Fig. 2. Our data appear to be better confined around zero (about 0.4″) than the (o-c) points from the other surveys (about 0.6″). Similar analysis carried out separately for each telescope used by our network arrives at similar results, with even better (o-c) confinement in the case of the ESO/MPG 2.2 m and LCO 1 m datasets.

3.1. Recovered VIs, PHAs, and NEAs

Besides NEAs selected from the Spaceguard and MPC object lists, we checked during a few runs also the MPC NEO confirmation list. Six minor planets were recovered by EURONEAR at OHP, CTIO, and LCO within one day from discovery, following their alert on the MPC list, while another four could not be recovered. The recovered objects are marked by (*) in the Appendix.

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[11] They used USNO-B1.

The recovered objects are: 2007 JX_2 (MPEC 2007-J32) – PHA discovered by Catalina and recovered by EURONEAR at OHP 1.2 m (formerly 7J2E987); 2008 KE_6 (MPEC 2008-K63) – PHA discovered by Catalina and recovered by EURONEAR at CTIO 1 m (formerly 8K85BC5); 2008 KN_{11} (MPEC 2008-K66) – VI discovered by Catalina and recovered by EURONEAR at CTIO 1 m (formerly 8K86577); 2008 UQ_2 (MPEC 2008-U45) – MBA discovered by Catalina and recovered by EURONEAR at LCO 1 m (formerly 8UB57EF); 2008 UT_2 (MPEC 2008-U48) – NEA discovered by Catalina and recovered by EURONEAR at LCO 1 m (formerly 8UB733D) and 2008 UR_2 (MPEC 2008-U46) – NEA discovered by Spacewatch and recovered by EURONEAR at LCO 1 m (formerly SW40ea).

Part of the observed NEAs, EURONEAR observed one NEA having a very large sigma uncertainty, namely 2008 JA_8, discovered by CSS on May 5, 2008, which was recovered by EURONEAR at CTIO 1 m about 10′ away from predicted position, later being tracked back and identified with a NEAT 2001 observation thanks to EURONEAR that defined its orbit.

3.2. Astrometry and orbit adjustment: the case of 2008 CR_{118} as a scholarship example

The astrometry performed by EURONEAR contributes to the improvement of the orbital elements of NEAs. These elements are updated regularly by several services and teams (e.g. MPC, NEODyS, ASTORB). These new orbital elements are dependent on several factors, such as the initial conditions of the adjustment, the weight of individual observations, the procedure of the adjustment of observations, the precision (double, quadruple) in the procedure, the dynamical system used for the integration, and the choice of the numerical integrator.

It is important to note that the adjustment is mandatory for objects for which one has a poor knowledge of their orbital parameters. This occurs mainly in two situations: i) the object was not observed for a long time, and ii) the object is a new discovery.

We propose to investigate this problem in a non-exhaustive way for our whole sample and to provide an example of such new observations, thus underlining the importance of an orbital adjustment of NEAs. We will concentrate on the asteroid 2008 CR_{118} as a generic example of the situation described below.

We computed the orbital elements of the NEA 2008 CR_{118} from 80 individual observations, obtained between March 2003 and October 2008. Ten of these astrometric observations were obtained by EURONEAR in Las Campanas (IAU code 304), on Oct. 22, 2008. When the EURONEAR observations were performed, the estimated uncertainty of the MPC ephemeris was around 20″.

In our investigation we used two different approaches to quantify the importance of these new observations. The first approach which we used was NOE-AST, derived from Lainey et al. (2007), Lainey (2008), and Lainey & Vienne (2009). This procedure uses the dynamical model DE406. The treshold of the adjustment in the procedure was established at 3σ, while the numerical integration was based on Gauss-Radau polynomials (Everhart 1985). The second approach, ASTERPRO (Rocher 2007; Bec-Borsenberger & Rocher 1988), is a specific procedure of adjustment and orbital element computation developed by Patrick Rocher. This procedure uses the dynamical model SLP98 (G. Francou, personal communication), the post-newtonian correction, χ^2 minimization procedure and K-student test as well as the Bulirsch and Stoer numerical integrator.

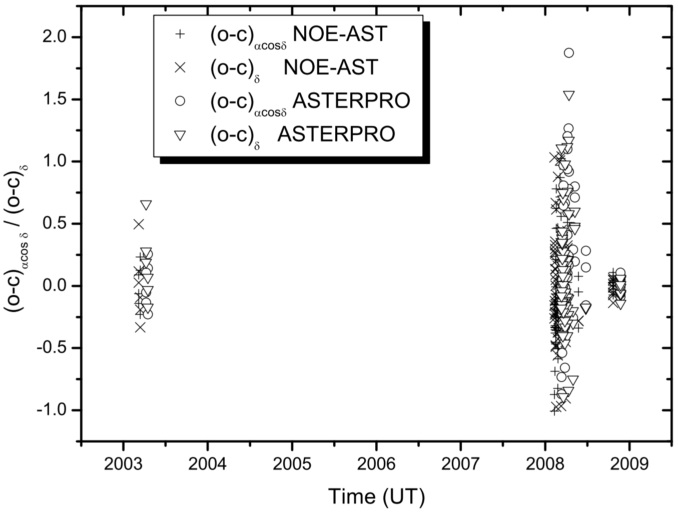

Fig. 6. The (o-c) values in right ascension and declination, correspondent to the adjustment of 2008 CR_{118} using NOE-AST and ASTERPRO.

We used the orbital elements for the epoch June 18, 2009, proposed by the Lowell Observatory[12] as initial conditions in our adjustment, and the weight of each observation was considered equal to the unity (i.e. independent observations).

The reliability of the results after the adjustment was checked using several NEAs, by comparing the rectangular coordinates X, Y, and Z and their first derivatives $\dot{X}$, $\dot{Y}$, and $\dot{Z}$, as well as the (o-c) values of the observations which were retained for the final solution. Globally the differences in rectangular coordinates are below 10^{-7}–10^{-6} AU, at values similar to the standard deviation of the observations. In the case of 2008 CR_{118}, these values are 10^{-6}, 0.6×10^{-6}, and 10^{-7} AU for X, Y, and Z respectively (i.e. less than 1 km of difference). These differences correspond to excursions of semi-major axis of less than 10^{-7} AU and less than 3×10^{-7} in eccentricity. The correspondent (o-c) in right ascension and declination are presented in Fig. 6.

We applied these two methods of adjustment to the asteroid 2008 CR_{118} in two situations: i) the case of the observation sample on which we extracted the observations from October 22, 2008, (Obs-without-EURONEAR) and ii) the case of a sample including all observations (Total-Obs). Then, the comparison of results would give an estimation of the improvement in the orbital coordinates, in NOE-AST and ASTERPRO approach respectively.

The results of the differences in coordinates and velocities (Total-Obs minus Obs-without-EURONEAR) are presented in Table 3. We conclude an important influence of the observations of Oct. 22, 2008 in the cartesian coordinates of the asteroid. Thus, for the X cartesian coordinate, the differences are 1995.6 km and 3383.1 km for NOE-AST and ASTERPRO respectively, which is more important by two orders than that for the Y coordinate. Relatively important differences are also calculated for the Z coordinate (358.6 km and 446.8 km for NOE-AST and ASTERPRO respectively). Consequently, this is translated in differences of 10^{-7} in the semi-major axis and 0.8×10^{-6} in eccentricity, for both the NOE-AST and ASTERPRO methods.

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[12] `ftp://ftp.lowell.edu/pub/elgb/astorb.dat.gz`

Table 3. Comparison of the differences of rectangular coordinates and velocities calculated for the asteroid 2008 CR_{118} using two adjustment procedures.

Coordinate MODEL	X ($\times10^{-6}$ AU)	Y ($\times10^{-6}$ AU)	Z ($\times10^{-6}$ AU)	$\dot{X}$ ($\times10^{-7}$AU/day)	$\dot{Y}$ ($\times10^{-7}$AU/day)	$\dot{Z}$ ($\times10^{-7}$AU/day)
NOE-AST	13.340	–0.082	2.397	0.229	0.039	–0.004
ASTERPRO	22.615	–0.208	2.987	–0.323	0.171	0.038

Table 4. Sample of orbit adjustment (semi-major axis for briefness here) and MOID calculated with observational datasets available immediately before and after our observations, compared with the complete dataset available on July 6, 2009.

Asteroid	a before	a after	a present	MOID before	MOID after	MOID present
2006 KD1	1.610261	2.482955	2.483163	0.35501	0.41254	0.41225
2008 KE6	0.815169	1.487399	1.685202	0.00177	0.01904	0.02243
2008 KF6	2.279096	2.298772	2.325204	0.03458	0.03719	0.03864
2008 KN11	1.733161	1.694478	1.708350	0.00101	0.00099	0.00099
2008 UT2	1.795989	1.798609	1.804049	0.02341	0.02359	0.02357
2008 EM7	1.230006	1.240259	1.238430	0.02553	0.01720	0.01864

3.3. Brief orbital study of VIs, PHAs, and recovered NEAs

All together, EURONEAR observed 66 VIs, PHAs and recovered NEAs, according to their classifications available at the observing epoch (online Table). We considered these cases to fit the orbits and derive the semi-major axis (a) and Minimum Orbital Intersection Distances (MOID) from orbits fitted to the observational datasets available immediately before and after our observations, as well as those resulting from the fit of all data available at present (e.g., including all observations after our runs). To perform the orbital fitting we used the ORBFIT package[13] and the asteroids' observational data from NEODyS[14]. Table 4 includes some results which show several important cases where the EURONEAR contribution can be seen.

3.4. Photometry of NEAs

Most NEAs observed by EURONEAR had magnitudes between $V = 19 \div 20^{\rm m}$ (1 m class telescopes) as faint as $V = 22^{\rm m}$ for the 2.2 m telescope (see Table in the Appendix), compatible with or complementing to other major surveys. Most observations were obtained using the Johnson or Cousins R filter. In the case of faint asteroids, no filter was used to maximize the recording of the Sun flux reflected by the body.

One of the NEAs observed in Las Campanas, 1994 AW_1, was actually the main target of a campaign focused on acquiring photometric data for a few selected binary asteroids (mostly Main Belt) to constrain the distribution of their orbital poles (Čapek & Vokrouhlický 2004). A few weeks previous to our 1 m telescope observations in Chile, 1994 AW_1 was observed using the 1 m telescope at SAAO in South Africa in poor weather conditions. By joining the two datasets we could obtain a better precision for the orbital and rotation periods.

A fast rotation period of the primary 1994 AW_1 was derived, $P_{\rm syn} = 2.5193 \pm 0.0001$ h. The amplitude of the lightcurve was $0^{m}.17$. The orbital period of the system, $P_{\rm orb} = 22.38 \pm 0.01$ h, was obtained after realizing that only primary events (magnitude attenuation) were observed in February and in March 2008. The rotation period of the satellite coincides with its orbital period and the amplitude of the lightcurve (without fitted component from the rotation period of the primary) is at least $0\overset{\rm m}{.}10$. The fits to the binary model in Fig. 7, which show the orbital period and in Fig. 8 the rotation period of the binary system. We compared the previous results of Pravec & Hahn (1997) with ours, and the results are similar despite the change in the geometry of the system by about 50° in longitude and 30° in latitude (if one takes into account the so-called phase-angle bisector).

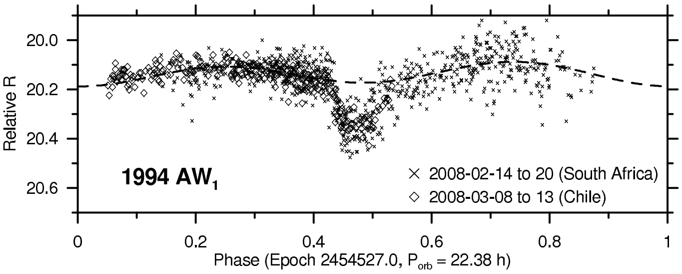

Fig. 7. Composite lightcurve of the binary system 1994 AW_1 after subtraction of the short period. The dashed line is the assumed fit of the lightcurve, which does not cover the whole period.

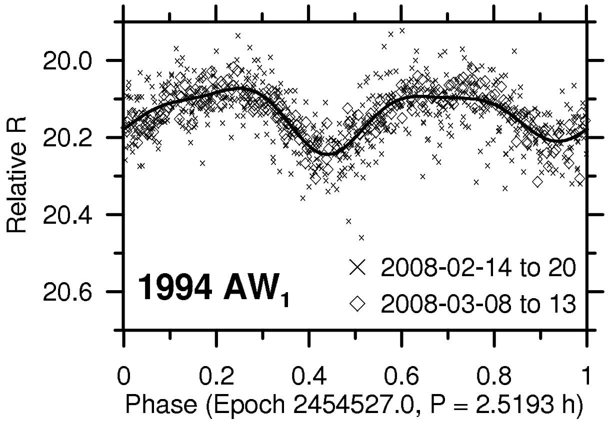

Fig. 8. The composite lightcurve of the primary body of the binary system 1994 AW_1.

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[13] `http://adams.dm.unipi.it/~orbmaint/orbfit/`

[14] `http://newton.dm.unipi.it/neodys/`

Photometry and physical data of binary NEAs are rather sparse, mainly because photometry is a task very time-consuming which requires a few nights or weeks to derive rotational and orbital periods for only a few systems. For most telescopes the observations for long periods seems to be incompatible with the policy of granted observing time. However, studies of physical properties of binary NEAs as well as their dynamical evolution are essential for the near future. In this regard, it is clear that a co-ordinated network to include at least two telescopes would be preferable, and EURONEAR could contribute in the near future with photometric data for NEA physical studies.

3.5. Discovery of MBAs and NEAs

Some of the NEAs followed-up by EURONEAR were located close to the ecliptic plane, and consequently many objects with proper motion compatible with MBAs could be identified in the observed fields. Besides the surveyed NEAs, data reducers closely inspected the entire fields, identifying and measuring all moving bodies using the convenient blink function of Astrometrica.

Most moving objects identified in the larger fields of 1 m telescopes (CTIO, LCO, OHP) were identified as known MBAs. Some others were not known and were detected in the runs at Las Campanas 1 m and ESO/MPG 2.2 m, thanks to the larger FOV and larger aperture in the second case. All together, we identified, measured and reported to MPC some 50 unknown moving bodies in the LCO 1 m run (five nights in Oct 2008 observing some 50 fields covering about 6 sq. degree) and about 450 unknown bodies in the ESO/MPG run (Mar. 2008 observing some 42 WFI fields covering about 21 sq. degree). To date, 56 objects observed at ESO/MPG have been officially considered EURONEAR discoveries by the MPC.

One set of eight images observed at the ESO/MPG during one night shows a well-visible set of longer collinear trails (about 25 pixels each), which suggests an object moving quite fast (about 10 arcsec/min), which could not be linked to any known NEA or PHA. We speculate that the accidental encounter of one new NEA during this three night run with ESO/MPG equipped with WFI mosaic camera could be compatible with the results of Boattini et al. (2004). In 2002 Boattini et al. (2004) discovered three NEAs during three clear nights using ESO/MPG at a time when the number of known NEAs was much less. Unfortunately, our object was observed for about 15 min only during one night, so it is impossible to establish an orbit, but it is expected to be linked to another object sometime soon. It is out of the scope of this paper to present our MBA discoveries, so we plan to investigate them statistically in the context of the MBA populations and 2 m survey capabilities at the faint end (mag $V \approx 22^{\rm m}$).

4. Conclusions and perspectives

EURONEAR network has been organized to increase the collaboration, mostly European, between professional astronomers, amateurs and students interested in NEAs. The optimization of this collaborative work of observations and astrometric data reduction is possible via a dedicated website which includes some specific software and a dedicated list of emails.

Astrometry has been the main tool of research for orbital properties. Overall, 162 NEAs, summing more than 1500 individual positions observed over a total of 55 nights between 2006 and 2008 were reported by the EURONEAR network and used in the orbital adjustment of NEAs (NEAs, PHAs, VIs). These results are published in the catalog EURONEAR_Release1. Some orbital fits run as examples with some models such as NOEAST, ASTERPRO, and ORBFIT including our datasets were compared with those obtained before our observations, clearly probing the contributions of our runs. Photometry is the main tool of research for basic physical properties of NEAs, and in this sense the NEA binary system 1994 AW_1 was observed, and we derived its rotation and orbital period.

About 500 new objects, whose motions are compatible with MBAs were reported as potential serendipitous discoveries in Las Campanas 1 m and La Silla 2.2 m, thanks to their large field and aperture capabilities. From these objects, 56 MBAs are officially recognized by the MPC as new discoveries. One object is speculated to be a new NEA which was possibly lost.

The (o-c) plots for all our observations show that most of our reduced data remained confined within $1''$, probing the observational capabilities for all facilities and the accurate data reduction. Considering our whole reduced dataset, the average astrometric position error has a $FWHM$ of $0.4''$ consistent with the USNO-B1 catalog uncertainty. This value is two times lower for the ESO/MPG observations, which benefit by the 2 m aperture and a large field. For the future, we intend to decrease these errors by employing unique dedicated reduction pipeline based on CPL procedures which uses UCAC-2 and UCAC-3 catalogs. These results are about two to three times better than those reported by other major surveys dedicated mainly to the discovery of new objects, which use much larger pixel scales and other observing protocols.

An important contribution could be obtained in the NEA research using 1 m class and even smaller telescopes, and this task was achieved during the last three years by the EURONEAR network, which used nine telescopes located in four countries in a team effort. Other runs are planned in the future on 1–2 m class telescopes to our specific objectives, while some funding continue to be searched in order to dedicate one or two 1–2 m class telescopes to the EURONEAR project.

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Appendix A

Table A.1. The observing log file.

Observatory	Asteroid	Class	Date (UT)	App mag (V)	Exp time	Nr pos	μ	Obs–Dis
Pic du Midi	2006 HV57	NEA	2006 May 16	19.2	300	10	0.5	18d
	2006 JU	NEA	2006 May 16	19.6	300	10	0.9	13d
	2006 JU41	NEA	2006 May 17	19.8	300	5	0.7	9d
	2006 HV57	NEA	2006 May 18	19.3	300	8	0.5	20d
	(144898) 2004 VD17	VI	2006 May 18	19.7	180	11	0.9	2y
	2006 JF42	PHA	2006 May 18	18.2	120	10	2.1	7d
	(139211) 2001 GN2	PHA	2006 May 19	19.2	120	10	1.5	5y
	2006 GW2	NEA	2006 May 19	19.2	300	10	0.1	40d
	2006 HQ30	PHA	2006 May 21	19.0	240	9	1.6	30d
	1997 XR2	PHA	2006 May 22	19.7	300	1	1.5	9y
	2006 KB1	NEA	2006 May 23	18.5	120	4	2.8	2d
	2006 KD1	PHA	2006 May 23	18.3	150	14	2.3	3d
	2006 KC	NEA	2006 May 24	18.8	120	16	3.4	5d
	(154715) 2004 LB6	NEA	2006 May 24	19.5	300	4	0.4	2y
Haute Provence	(68950) 2002 QF15	PHA	2006 May 28	14.6	60	16	5.1	4y
	(68950) 2002 QF15	PHA	2006 May 30	14.7	60	11	4.6	4y
	2007 FK1	NEA	2007 May 06	16.7	120	12	5.3	50d
	2007 FV42	NEA	2007 May 06	17.5	90	10	1.0	48d
	2007 FL1	NEA	2007 May 07	17.9	90	10	3.5	51d
	2007 DZ40	NEA	2007 May 08	18.0	90	5	3.3	76d
	(184990) 2006 KE89	NEA	2007 May 08	18.6	90	10	1.7	1y
	2006 GB	PHA	2007 May 08	19.1	120	10	2.2	1y
	2007 DF8	NEA	2007 May 08	19.6	180	10	1.3	75d
	2007 DT103	PHA	2007 May 08	19.7	300	2	0.3	71d
	2007 HX4	NEA	2007 May 09	19.9	300	7	2.7	18d
	2007 FE1	NEA	2007 May 09	19.8	180	11	1.4	51d
	2007 JX2 *	PHA	2007 May 09	19.0	60	11	4.6	1d
	2006 HR29	NEA	2007 May 09	17.9	60	8	3.3	1y
	2007 HX82	NEA	2007 May 09	19.7	180	11	1.4	13d
	2006 VY13	NEA	2007 May 10	19.7	300	4	0.6	1y
	2007 CQ5	NEA	2007 May 10	19.3	180	7	1.4	93d
	2007 JW2	NEA	2007 May 10	19.1	180	10	1.8	3d
	2006 WL3	NEA	2007 May 10	19.8	300	6	1.8	1y
Cerro Armazones	2007 VD12	PHA	2007 Nov. 17	16.4	60	19	2.7	12d
	2007 VY7	NEA	2007 Nov. 17	17.9	120	10	1.8	7d
	2006 US216	PHA	2007 Nov. 17	18.5	120	14	2.7	1y
	2007 TD71	PHA	2007 Nov. 18	19.5	120	4	3.6	36d
	2007 GS3	PHA	2007 Nov. 18	18.1	90	18	2.8	1y
	2007 VT6	PHA	2007 Nov. 18	18.6	60	8	3.2	15d
Cerro Tololo	2008 JZ7	NEA	2008 May 30	19.4	60	11	2.0	25d
	2008 JO	NEA	2008 May 30	19.6	60	7	2.4	28d
	2008 HF2	NEA	2008 May 30	19.0	30	8	5.2	34d
	2008 FS6	NEA	2008 May 30	19.4	60	5	0.7	64d
	2008 DY	NEA	2008 May 30	19.8	60	10	1.4	66d
	2008 JS26	NEA	2008 May 30	18.9	30	10	6.7	16d
	2008 JU2	NEA	2008 May 30	18.9	30	12	7.1	27d
	2007 XH16	PHA	2008 May 30	19.3	60	10	2.7	1y
	2008 JW2	PHA	2008 May 30	19.1	60	10	1.4	27d
	2007 YB2	NEA	2008 May 30	20.0	120	8	0.7	1y
	2008 KE6 *	NEA	2008 May 30	19.9	30	6	4.7	1d
	2008 JA8 *	NEA	2008 May 30	19.0	30	11	3.5	25d
	2008 EZ97	NEA	2008 May 30	18.1	30	11	2.0	76d
	2008 JY30	NEA	2008 May 30	18.4	20	9	9.4	16d
	2008 DE	PHA	2008 May 30	18.0	20	10	2.3	77d
	2007 WV4	PHA	2008 May 30	19.5	30	3	4.4	1y
	2008 FN6	NEA	2008 May 31	19.1	30	10	4.9	61d
	2008 CP23	NEA	2008 May 31	19.8	60	4	2.3	120d

Table A.1. continued.

Observatory	Asteroid	Class	Date (UT)	App mag (V)	Exp time	Nr pos	μ	Obs–Dis
	2008 KV2	NEA	2008 May 31	18.3	15	10	4.7	3d
	2008 KF6	VI	2008 May 31	18.6	15	10	9.1	1d
	2008 KW2	NEA	2008 May 31	18.1	15	9	5.3	3d
	2008 KN11*	VI	2008 May 31	20.4	60	12	1.1	1d
	2008 EC69	PHA	2008 May 31	17.1	20	9	5.4	100d
	2008 JJ	NEA	2008 Jun. 01	16.2	10	2	11.6	32d
Las Campanas	1994 AW1	PHA	2008 Mar. 08	18.0	60	49	1.2	14y
	2005 TJ174	NEA	2008 Jun. 04	19.0	120	5	0.8	3y
	2008 KB12	NEA	2008 Jun. 05	18.5	20	8	7.3	7d
	2005 UY5	NEA	2008 Jun. 06	18.7	60	8	0.7	3y
	2008 TC4	NEA	2008 Oct. 18	18.1	15	15	9.9	12d
	2008 RS26	NEA	2008 Oct. 18	19.5	150	10	0.7	46d
	2008 KZ5	PHA	2008 Oct. 18	18.4	45	16	3.6	142d
	2008 TX3	NEA	2008 Oct. 18	18.9	30	16	4.4	12d
	2001 SG10	PHA	2008 Oct. 18	19.0	60	16	1.9	7y
	(190491) 2000 FJ10	NEA	2008 Oct. 18	17.0	15	16	6.1	8y
	2007 TA19	PHA	2008 Oct. 18	19.6	45	16	2.8	1y
	(171576) 1999 VP11	PHA	2008 Oct. 18	17.4	15	11	7.3	9y
	2006 WR1	NEA	2008 Oct. 19	19.8	45	15	2.8	2y
	2005 UH6	PHA	2008 Oct. 19	19.7	30	15	3.9	3y
	2008 QT3	PHA	2008 Oct. 19	19.2	150	10	0.1	54d
	2008 TD4	NEA	2008 Oct. 19	19.0	50	15	2.5	12d
	2008 TN26	NEA	2008 Oct. 19	19.9	90	12	2.2	10d
	2008 SR1	NEA	2008 Oct. 19	19.9	180	15	0.3	26d
	2008 QZ	NEA	2008 Oct. 19	19.3	180	10	0.2	58d
	2008 SP7	NEA	2008 Oct. 19	18.5	60	15	1.3	26d
	2008 SJ82	NEA	2008 Oct. 19	19.9	90	14	1.6	23d
	2008 MH1	NEA	2008 Oct. 22	19.3	40	15	2.6	119d
	2008 OB9	PHA	2008 Oct. 22	20.6	200	15	0.5	89d
	2008 CR118	PHA	2008 Oct. 22	19.8	45	10	2.0	245d
	2008 RG98	NEA	2008 Oct. 22	19.2	90	9	1.5	42d
	2008 SE85	NEA	2008 Oct. 22	19.6	30	10	4.8	24d
	2008 TV25	NEA	2008 Oct. 22	18.7	30	10	4.4	13d
	2008 SU1	NEA	2008 Oct. 23	18.5	20	6	5.2	30d
	2008 SX7	NEA	2008 Oct. 23	19.4	60	7	2.1	32d
	2008 SW150	NEA	2008 Oct. 23	20.1	60	7	2.2	24d
	2008 UC	NEA	2008 Oct. 23	19.1	60	8	0.4	34d
	2008 TF4	NEA	2008 Oct. 23	19.2	50	8	2.2	17d
	2008 RE80	NEA	2008 Oct. 23	20.2	120	6	0.8	42d
	2008 TE157	NEA	2008 Oct. 23	20.2	100	8	0.9	21d
	2008 TJ157	NEA	2008 Oct. 23	20.6	120	6	1.1	17d
	2008 TK157	NEA	2008 Oct. 23	19.2	60	8	0.5	30d
	2008 TA1	NEA	2008 Oct. 23	20.1	120	6	1.4	21d
	2008 RP108	NEA	2008 Oct. 23	20.0	120	6	0.2	43d
	2008 SX245	NEA	2008 Oct. 23	19.4	60	8	1.1	24d
	2008 SS251	NEA	2008 Oct. 23	20.3	120	8	0.2	27d
	2008 QD1	NEA	2008 Oct. 23	18.7	90	6	0.9	60d
	2008 SO1	NEA	2008 Oct. 23	19.8	45	6	3.1	31d
	2008 SV7	NEA	2008 Oct. 23	19.9	60	7	2.4	29d
	2008 SQ7	NEA	2008 Oct. 23	19.4	30	4	4.4	30d
	2008 UT2 *	NEA	2008 Oct. 24	20.0	20	5	4.9	1d
	2008 UR2 *	NEA	2008 Oct. 24	19.8	40	8	3.7	1d
	2002 TW55	PHA	2008 Oct. 24	18.7	20	9	7.1	6y
	2001 SG10	PHA	2008 Oct. 24	19.1	60	10	1.5	7y
	2005 WK4	PHA	2008 Oct. 24	19.5	60	10	1.8	3y
	2001 KO20	NEA	2008 Oct. 24	20.0	60	10	1.0	7y
	2008 TT26	NEA	2008 Oct. 24	15.2	3	5	41.0	15d
	2001 UY4	PHA	2008 Oct. 24	16.8	10	10	8.8	7y
	2008 MB5	NEA	2008 Oct. 24	20.2	80	9	1.6	114d
	2008 RT26	NEA	2008 Oct. 24	20.1	80	8	1.5	47d

Table A.1. continued.

Observatory	Asteroid	Class	Date (UT)	App mag (V)	Exp time	Nr pos	μ	Obs–Dis
La Silla 1 m	2007 PA8	VI	2007 Aug. 13	19.2	120	4	0.8	4d
	2007 FV42	NEA	2007 Aug. 13	16.5	120	12	0.4	1y
La Silla 2.2 m	2008 EA8	VI	2008Mar. 11	21.4	60	14	2.7	5d
	2008 EX5	VI	2008 Mar. 11	20.3	60	15	2.4	7d
	2008 EM7	VI	2008 Mar. 11	20.6	60	15	3.1	5d
	2008 ER7	VI	2008 Mar. 11	20.7	60	13	1.8	5d
	2005 GE59	PHA	2008 Mar. 11	20.6	60	14	0.8	3y
	(162173) 1999 JU3	PHA	2008 Mar. 12	17.9	60	15	3.4	9y
	2008 EL6	PHA	2008 Mar. 12	17.2	10	17	15	7d
	(162173) 1999 JU3	PHA	2008 Mar. 13	17.9	60	8	3.4	9y
	2006 GZ	NEA	2008 Mar. 13	21.3	120	8	0.9	2y
	2008 DA4	VI	2008 Mar. 13	22.0	120	8	1.0	2y
	2008 CE6	NEA	2008 Mar. 13	21.2	120	8	0.8	33d
	2008 DL5	PHA	2008 Mar. 13	19.7	30	8	4.0	13d
	2008 EJ9	NEA	2008 Mar. 13	20.0	60	7	5.2	4d
	2008 EQ7	NEA	2008 Mar. 13	20.1	60	5	2.4	7d
	2008 DJ5	NEA	2008 Mar. 13	20.3	60	5	1.5	13d
	2008 EA9	VI	2008 Mar. 13	21.0	60	5	2.4	7d
Urseanu	(1980) Tezcatlipoca	NEA	2006 Nov. 07	13.7	15	3	3.0	56y
	(5143) Heracles	NEA	2006 Nov. 13	14.5	15	3	2.4	53y
	2007 PU11	NEA	2007 Oct. 16	15.1	15	7	2.2	18y
	2007 TS19	PHA	2007 Oct. 16	16.0	15	4	9.2	6d
	(4954) Eric	NEA	2007 Nov. 02	12.3	15	3	2.1	32y
	(3200) Phaethon	PHA	2007 Nov. 28	14.0	15	3	5.2	24y
	(1036) Ganymed	NEA	2007 Nov. 29	13.4	15	3	0.6	83y
	(3288) Seleucus	NEA	2008 Jan. 28	15.7	15	3	1.0	26y
	2007 TU24	PHA	2008 Jan. 30	11.6	15	3	36.7	90d
	(1620) Geographos	PHA	2008 Feb. 25	12.8	15	3	3.6	57y
	1998 YP11 (11398)	NEA	2008 Mar. 23	14.7	15	7	3.3	25y
	(1685) Toro	NEA	2008 Mar. 03	14.7	15	4	2.1	60y
	(170891) 2004 TY16	NEA	2008 Mar. 03	15.9	15	4	2.1	4y
	2008 CL1	NEA	2008 Mar. 09	16.1	15	4	10.2	34d
	(179806) 2002 TD66	PHA	2008 Mar. 09	16.6	15	3	4.2	6y
	2005 NB7	PHA	2008 Apr. 20	14.8	15	4	15.8	3y
	(137170) 1999 HF1	NEA	2008 Apr. 20	15.4	15	4	1.9	9y
	(35107) 1991 VH	PHA	2008 May 01	16.8	15	7	1.4	17y
	(53319) 1999 JM8	PHA	2008 May 01	15.8	15	7	3.3	9y
	2008 HW1	NEA	2008 May 05	16.7	15	11	8.8	36d
	2008 JT35	PHA	2008 Jun. 30	16.0	10	5	11.4	55d
	(185851) 2000 DP107	PHA	2008 Oct. 01	15.1	15	3	3.2	8y
	(164400) 2005 GN59	PHA	2008 Oct. 03	14.1	15	3	14.2	3y
	(137032) 1998 UO1	NEA	2008 Oct. 03	14.0	15	4	10.2	10y
	(16960) 1998 QS52	PHA	2008 Oct. 10	14.3	15	6	4.8	10y
York University	(35396) 1997 XF11	PHA	2002 Nov. 09	13.8	20	23	7.6	5y
	(65803) Didymos	PHA	2003 Dec. 04	13.7	60	35	2.7	7y
	(4179) Toutatis	PHA	2004 Aug. 22	13.1	50	20	0.4	70y
	(4179) Toutatis	PHA	2004 Sep. 12	11.9	30	20	1.2	70y

Notes. For each telescope location, the name of asteroid, its type, the date of observations, the apparent magnitude, the exposure time and the number of observations are presented. The table contains also the apparent motion of the asteroid at the time-period (d-days, y-years) between its discovery and the EURONEAR observation.

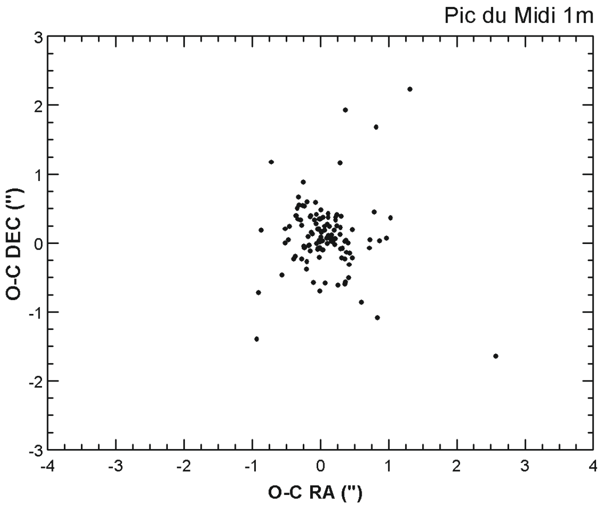

Fig. A.1. Pic du Midi 1 m: (o-c) residuals for 122 positions of 14 NEAs observed by EURONEAR in one run.

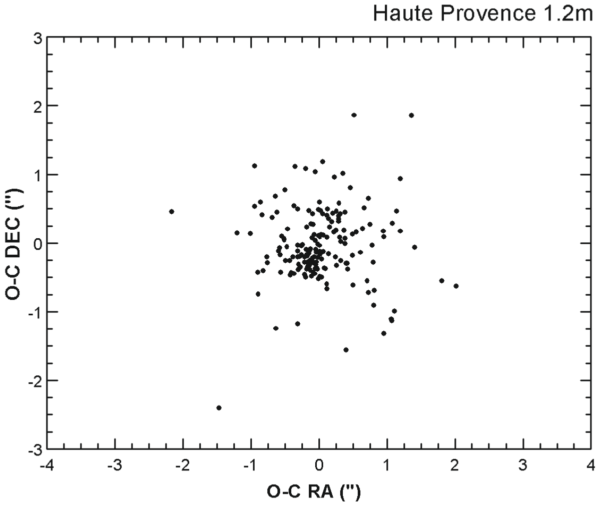

Fig. A.2. Haute Provence 1.2 m: (o-c) residuals for 171 positions of 19 NEAs observed by EURONEAR in one run.

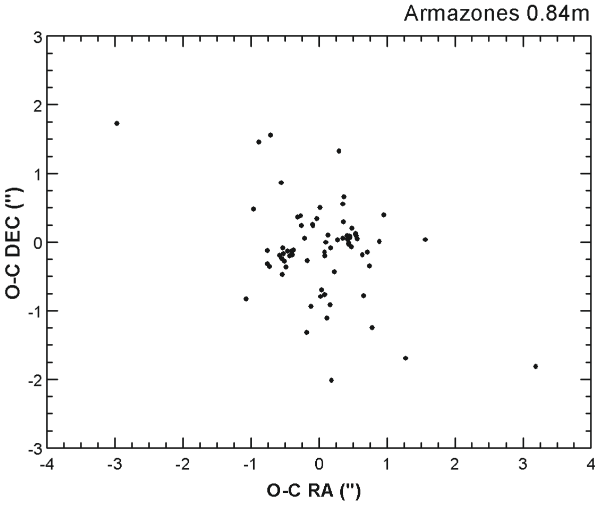

Fig. A.3. Armazones 0.84 m: (o-c) residuals for 73 positions of 6 NEAs observed by EURONEAR in one run.

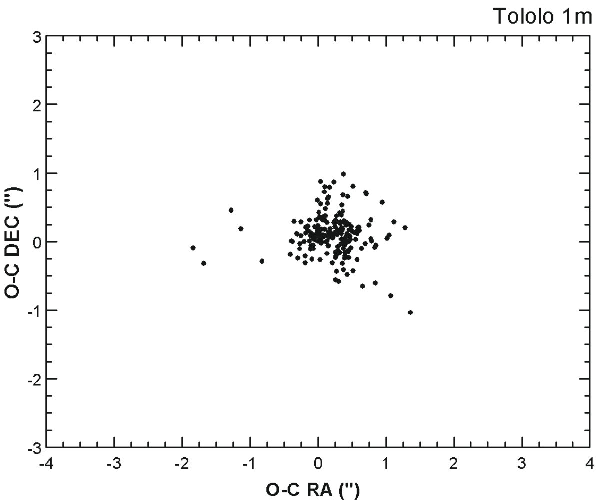

Fig. A.4. Tololo 1 m: (o-c) residuals for 207 positions of 24 NEAs observed by EURONEAR in one run.

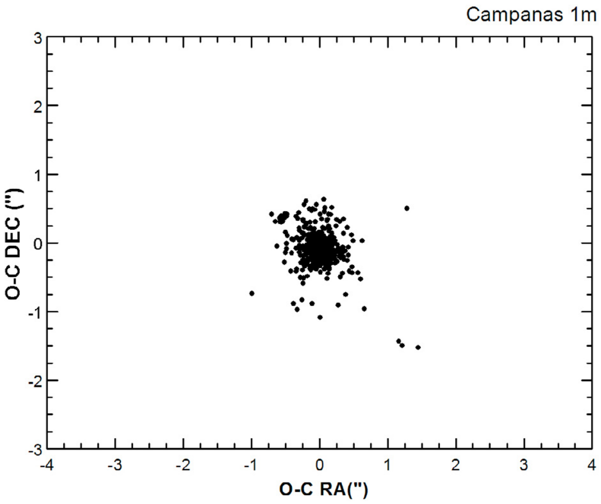

Fig. A.5. Campanas 1 m: (o-c) residuals for 575 positions of 54 NEAs observed by EURONEAR in three runs.

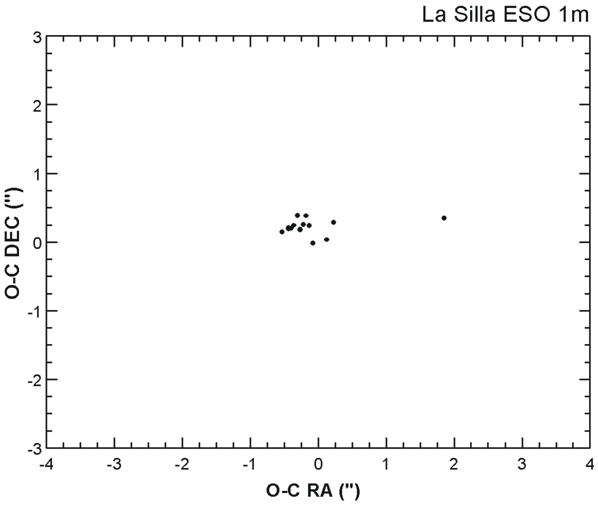

Fig. A.6. La Silla 1 m: (o-c) residuals for 16 positions of 2 NEAs observed by EURONEAR in one run.

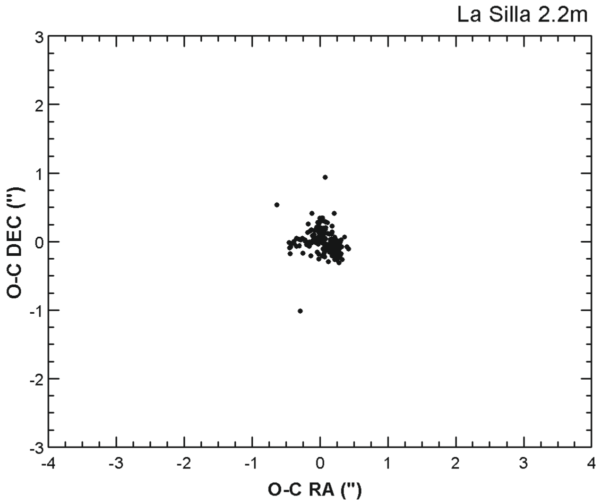

Fig. A.7. La Silla 2.2 m: (o-c) residuals for 165 positions of 15 NEAs observed by EUROEAR in one run.

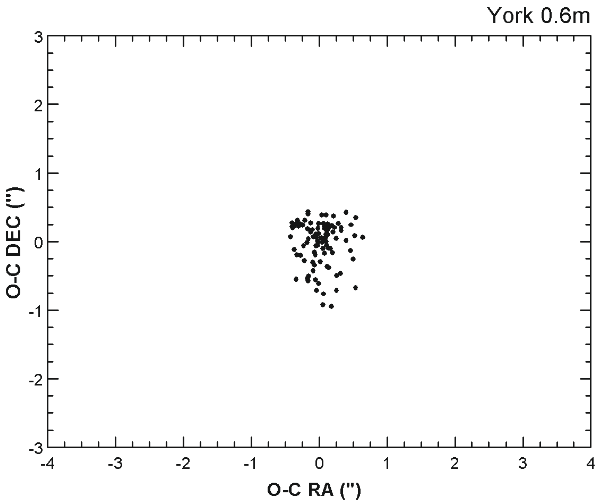

Fig. A.9. York University 0.6 m: (o-c) residuals for 98 positions of 4 NEAs observed by EURONEAR in 4 runs.

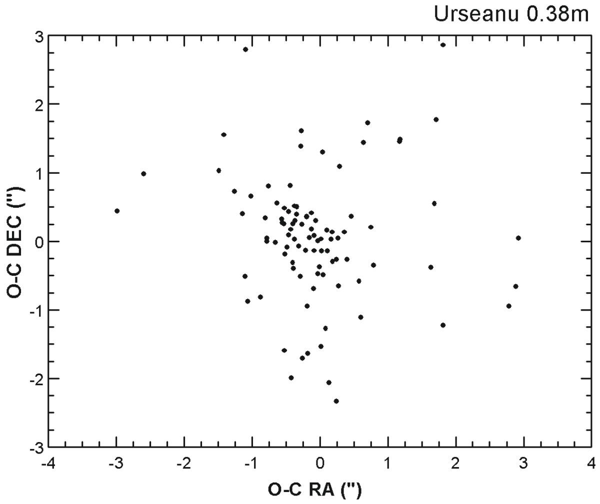

Fig. A.8. Urseanu 0.38 m: (o-c) residuals for 95 positions of 21 NEAs observed by EURONEAR in 18 runs.