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DIVISION III / SERVICE MINOR PLANET CENTER

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TRIENNIAL REPORTS 2003 - 2006, 2006 - 2009

1. Introduction

The activity of the *Minor Planet Center* continued generally to increase during the two triennia covered by this report, principally because of the continuing success of the surveys for near-earth objects. Chief among these has been the *Lincoln* (Laboratory) *Near-Earth Asteroid Research Project*, or LINEAR, which is credited with the discovery of slightly more than half of all the minor planets that have been numbered, although since 2005 the Catalina Sky Survey and Mount Lemmon Survey in Arizona and the Siding Spring Survey in New South Wales (all three of which, together with the long-lasting Spacewatch Survey, are operated from the University of Arizona) have come to dominate the field. The total number of observations of minor planets in the MPC's files more than doubled from 14.1 million in mid-2002 to 30.9 million in mid-2005, with almost another doubling, to 55.4 million, in mid-2008.

The rate of numbering new minor planets followed a similar pattern, with an increase from 43 721 in mid-2002 to 99 947 in mid-2005, almost doubling again to 189 005 in mid-2008. Since the numbering of a minor planet is the 'end product', with the assurance that such an object has been well-enough observed that it is unlikely to be lost in the foreseeable future, it is interesting to note that, while this mid-2002 figure represents only 23% of all the orbits of minor planets in the MPC collection at that time, the fraction had doubled to 46% by mid-2008. Of course, if this fractional evolution continues, there is an implication, either that the work of the MPC will soon be 'complete', or that the bulk of the recent observations are of objects recognized only on two neighboring nights. That the number of observations received actually decreased from 9.7 million during 2006 – 2007 to 8.5 million during 2007 – 2008 would seem to support the former hypothesis. This may be evidence that the current surveys are approaching the limits of what they can do. When next-generation observing programs such as Pan-STARRS and LSST start bearing fruit – i.e., routinely following up main-belt objects that are significantly fainter and smaller than now – the MPC will likely be more productive than ever.

2. Publications and archiving

The permanent archiving of data continues to be done essentially on a monthly basis, coinciding with the publication of the *Minor Planet Circulars* and the *Minor Planet Circulars Orbit Supplement*. As the traditional publication of the MPC, dating back to 1947, the former is now basically a summary of the MPC activity, the 17 236 pages

published during the double triennium bringing the total up to 63 316. Through 2005 this publication was available in both printed and electronic form, although the printed edition is now essentially restricted to the pages summarizing the new numberings and providing the citations for the new namings. The *Orbit Supplement* has been issued only electronically since its inception in 2000, and the 108 182 pages published since mid-2002 make for a total now of 140 228. There is also the *Minor Planet Circulars Observation Supplement*, an entirely electronic publication started in 1997 and generally issued weekly, with the 193 368 pages published during the two triennia increasing the total to 252 006.

In addition, there are the *Minor Planet Electronic Circulars*, the 10 137 of these issued during these six years bringing to 16 054 the total since the first one was issued in 1993. The main purpose of the *MPECs*, which are in fact available on the worldwide web without subscription, is to provide immediate information concerning unusual new discoveries, principally NEOs. A 'Daily Orbit Update' *MPEC* tabulates all the orbits computed at the MPC during the previous 24 hours. This DOU issue, which is prepared entirely automatically, is consistent with the intention that the *MPECs* should be a 'temporary' (unarchived) publication, for as long as further observations are made, orbit computations will always be improved. By popular request, the DOU *MPECs* do also include continuing observations of all NEOs. Again, this publication of observations cannot be considered archival, and the automatic preparation precludes the possibility of crediting the observers in a reliable manner.

3. Near-earth objects

Prior to the preparation of an *MPEC* documenting a discovery, alerts to possible NEOs are issued on "The NEO Confirmation Page". Although this webpage has existed since 1996, recent improvements have meant that entries can appear there automatically, as the automated procedures that extract all observations reaching the MPC by e-mail have been augmented to include some estimation of the probability that an object is an NEO. If this probability is greater than 50%, under appropriate circumstances the observations, initial attempts at representing the orbit, and tabulations and plots of the orbital uncertainty appear on the NEOCP within a matter of minutes. Furthermore, the predictions for an object already on the NEOCP are automatically updated as follow-up observations arrive. A particular improvement introduced in 2004 is color-coding of the positional uncertainty plots to indicate orbital solutions that could result in near-collision with the earth.

From 2003 to the present, 3 429 separate NEOs were discovered, and of these 508 are considered potentially hazardous asteroids (PHAs). These objects have minimum orbital intersection distances with the earth less than 0.05 AU and absolute magnitude $H < 22$. While more than 98% of the discoveries are made by professional astronomers, there is room for amateur astronomers to contribute to the NEO effort by performing astrometric follow-up of NEOs and NEO candidates.

4. Comets

Some of the NEO candidates appearing on the NEOCP turn out to be comets, and in cooperation with the Central Bureau for Astronomical Telegrams (a service of Division XII/Commission 6), the MPC sometimes places suspected comets (even if they cannot be NEOs) there deliberately, in the expectation of inspiring quick follow-up observations. After the initial discovery, observations and orbit computations of a comet are

routinely handled by the MPC, with temporary publication generally weekly on *MPECs* and monthly (with permanent archiving) in the *Minor Planet Circulars*. Some 260 000 observations of comets were published during 2002 - 2008, giving now a total of 412 000. Three editions of *Catalogue of Cometary Orbits* were issued, in 2003, 2005 and 2008. The 2008 edition contains 3 815 orbits for 3 708 cometary apparitions. These include 1 139 orbits for the 1 062 apparitions of the now 200 numbered comets (i.e., comets observed at multiple apparitions). There are also 1 490 near-sun comets observed only from SOHO and other space probes monitoring the sun.

5. Distant objects

Just 600 discoveries of 'Distant objects'(centaurs and transneptunian objects) were discovered during the double triennium, i.e., some 47% of the total found since 1992. Of the 600, 48% have so far been observed at only a single opposition, a number that actually suggests improvement in the recovery rate recently, given that this fraction is as high as 41% for distant objects as a whole.

Excluding the four 'plutoids', or transneptunian dwarf planets, there are 218 distant objects with orbits considered reliable enough that they have been numbered. Of these, 62 are obvious 'cubewanos', or 'classical Kuiper Belt' objects with orbital semimajor axes in the range 40-47 AU. This number increases to 71 if the range is increased to 37-52 AU. There are 25, or maybe 27 centaurs in the range of the giant planets (depending on how they are defined in terms of coupling with Jupiter), a number that increases to 41 if the semimajor axis is allowed to exceed that of Neptune. Adding what are generally considered 'scattered' (or 'scattering') disk objects (i.e., objects with perihelia somewhat beyond Neptune and generally quite eccentric orbits) augments this number to 48, while the total increases to 61 if similar objects that are considered to be 'detached' (generally with even larger perihelion distances, sometimes in excess of 45 AU) are included. There are then the objects in mean-motion resonance with Neptune, notably the 33 'plutinos', in the 2:3 resonance. The next most populated resonance may be 4:7, possibly with 13 members, although this number may be significantly overestimated, the 44 AU semimajor axis obviously inviting some confusion with cubewanos; less confusion surrounds the objects at the 3:5 resonance, at 42 AU. There is a very clear-cut group, with at least 7 members, at the 2:5 resonance (55 AU). Beyond the cubewanos there are also clearly objects at the 1:2, 3:7 and 1:3 resonances and very possibly at resonances of fifth order and even higher. Closer to the sun than the plutinos are objects at the 3:4 and 4:5 resonances, and while 'Neptune Trojans', at the 1:1 resonance, are known to exist, none has yet been numbered.

6. Outer satellites of the giant planets

Because of their potential confusion with minor planets, the MPC continues also to catalogue observations and to compute orbits for the outer satellites of the giant planets. Eleven new satellites of Jupiter discovered at the 2002 – 2003 opposition have been observed well enough to be numbered (and named), bringing the total to 49, but some listings give 62 (or more) – an unwise claim, given that these objects were observed *only* in 2003 (or in one case only in 2000). Seventeen discoveries of outer satellites of Saturn during 2003 – 2007 have also been numbered, bringing the total number of satellites of Saturn to 52; again, eight more presumed discoveries during 2004 – 2007 have not been confirmed at a second opposition. A new definite outer satellite or Uranus and five

satellites of Neptune were also discovered during 2002 – 2003, the total number of satellites for these planets now being 27 and 13, respectively.

7. Personnel

B. G. Marsden retired as MPC director in 2006 after serving in that capacity for 28 years; he continues to work principally with comets, distant objects, outer-planet satellites and on the monthly production of *Minor Planet Circulars*, as well as serve as secretary of the *Committee on Small-Body Nomenclature* and as MPC-CSBN representative on the Working Group for *Planetary System Nomenclature*. Marsden was succeeded as director by T. B. Spahr, who joined the MPC staff in 2000 and has principally been involved with NEOs, for several years also serving as liaison with other organizations working on NEOs. Spahr's workload has now increased with normal (and abnormal) administrative duties. G. V. Williams continues as MPC associate director, responsible for most of the MPC's computer software (and hardware), most of the organization of observations of and orbit computations on main-belt minor planets, and the lion's share of the preparation of the permanent MPC publications. K. E. Smalley (aka S. Keys), who joined the MPC staff as a contractor in 2002, became a full member in 2005 and is also involved extensively with writing software and working with NEOs. M. Lohmiller continues to serve as administrative assistant, attending in particular to e-mail address lists and other matters related to maintaining subscriptions to the MPC publications.

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