

**MACE 2006**

**Wien, 12-14 May 2006**

**NEW DEFINITION OF DISCOVERY  
FOR SOLAR SYSTEM OBJECTS  
AND DISCOVERY CREDIT RULES**

**Andrea Milani, Giovanni Federico Gronchi**

*Department of Mathematics, University of Pisa*

**Zoran Knežević**

*Astronomical Observatory, Belgrade*

# 1 DEFINITIONS: ACTORS

**Observer** Either a person or a team claiming credit for submitting some astrometric data and accepting that they become public.

**Orbit Computer** Either a person or a team claiming credit for submitting the results of computations, containing orbit solutions, with uncertainty, and identifications.

**IAU Data Center** The organization (with a mandate from the IAU) receiving and immediately publishing the data submitted by both Observers and Orbit Computers. It can also act as Orbit Computer, assign Discovery Credit and build a statistical Observation Error Model.

**Solar System Object (SSO)** Includes natural bodies orbiting in the Solar System: asteroids, comets, transneptunian objects, [natural satellites should be included, but theory is different]. [Problem: major planets. What is the definition? Who handles their data?]

## 2 DEFINITIONS: DATA

**Observation** A set of data uniquely defining a position on the celestial sphere at a given time, e.g., time, two angles (R.A., DEC.) and possibly an apparent magnitude. Should always be provided with the metadata necessary to assess the accuracy.

**Detection of a Moving Object (DMO)** An Observation corresponding to a real moving object, which is a SSO. In real cases (as opposed to simulations) we do not know which Observations are *false*, that is belong to no real body, which belong to a fixed star and which are DMO.

**Very Short Arc (VSA)** A number of OBS, possibly with ancillary data, which can be interpreted as a sequence of observations of one and the same SSO. Note a VSA should be proposed by the Observer, before any attempt to fit an orbit, in good faith, that is having done the best possible effort to ensure that it can be *true*. This is the type of data to be submitted to the Data Center.

### 3 DEFINITIONS: COMPUTED QUANTITIES

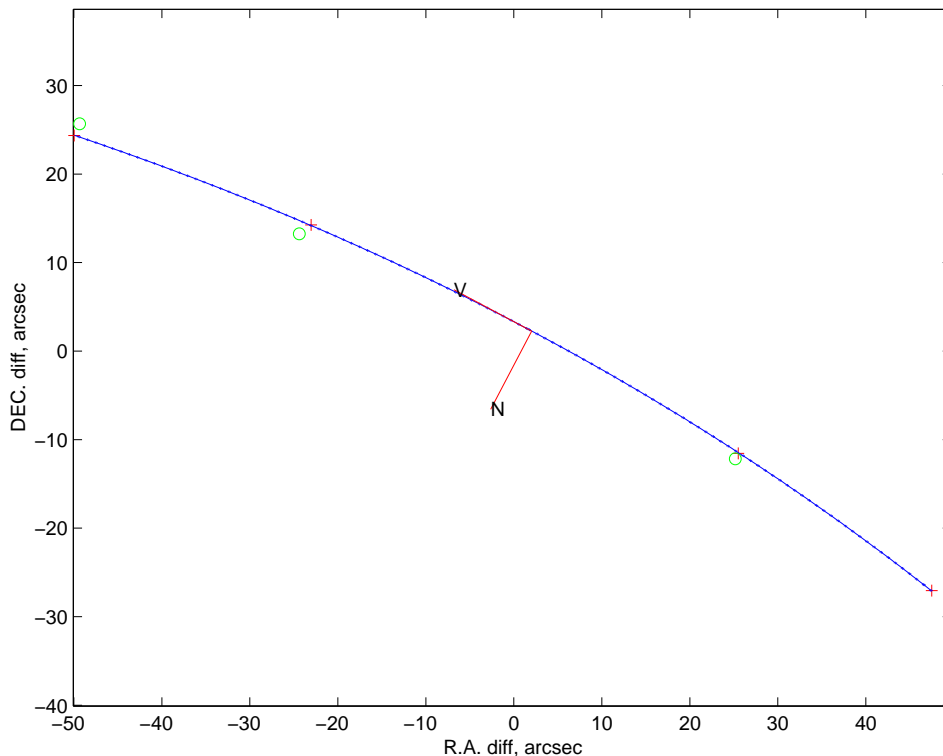
**Orbit** 6 orbital elements and an epoch time, uniquely defining an initial condition for the motion of a SSO. **Preliminary Orbit** if it fits the observations but is by no means determined by them, or **Least Squares Orbit** if it is obtained by a fit of the observations with 5 to 6 free parameters.

**Identification (ID)** A set of VSA, together with a Least Squares Orbit fitting all of them within the estimated accuracy of the observations.

**Observed Arc (ARC)** A set of observations, obtained by identifying a number of VSA, which can be interpreted as a sequence of DMO of one and the same SSO.

**Curvature** A measure of the deviation of the Observed Arc from a great circle, traced with uniform speed on the celestial sphere. The curvature is **Significant** if the deviations of the individual observations from a great circle cannot be due only to observational error (according to the Error Model).

## 4 DEFINITIONS: TOO SHORT ARC



**Too Short Arc (TSA)** An Observed Arc too short to compute a useful Least Squares Orbit. Most VSA are also TSA, because in modern surveys they are formed with OBS separated by a very short time, which does not allow for Significant Curvature.

**Attributable (ATT)** A mathematical object describing all the significant information contained in a TSA: a 4-dim vector (an arrow tangent to the celestial sphere) with a date and an optional apparent magnitude. A Least Squares Orbit cannot be computed from a TSA because there are essentially 4 constraints and either 5 or 6 free parameters.

## 5 DEFINITIONS: ARC TYPE, DISCOVERY

**Arc of Type N** An Observed Arc which can be split into exactly  $N$  disjoint TSA in such a way that each couple of TSA consecutive in time, if joined, would show a significant curvature. This definition is meant to replace the currently used definition of *N-nighter*, an observed arc containing observations belonging to exactly  $N$  distinct nights.

**Discovery** A set of observations of a SSO, forming an Observed Arc of Type  $N$  with  $N \geq 3$ . In almost all the cases such data are enough to compute a Least Squares Orbit with moderate uncertainty. It is also required that the data contain enough photometric information to fit an absolute magnitude.

**Discovery of a comet** A Discovery as above, complemented with enough observational data to prove that there is a directly detectable cometary activity.

## 6.1 NUMERICAL TEST ON MPC DATA

Using the November 2005 data update. In this test, the critical value of curvature is set at  $\chi = 1$ , of “Z-sign” at 3.

Arc Typ	Good orb curvature	Good orb no curv	Bad orb no curv	Bad orb curvature	Total
1	0	12	17,675	11	17,698
2	3,927	232	61,987	6,460	72,606
3	14,961	127	2,853	4,542	22,483
4	13,076	46	304	784	14,210
5	10,289	14	25	110	10,438
6	7,885	3	2	20	7,910
> 6	23,398	1	0	10	23,409

## 6.2 NUMERICAL TEST ON MPC DATA

Using the March 2006 data update. In this test, the critical value of curvature is set at  $\chi = 3$ , of “Z-sign” at 4.

Arc Typ	Good orb curvature	Good orb no curv	Bad orb no curv	Bad orb curvature	Total
1	0	87	56,114	12	56,213
2	14,117	319	36,781	11,124	62,341
3	17,916	53	126	1,443	19,538
4	14,646	7	5	72	14,730
5	10,630	0	0	7	10,637
6	7,321	0	0	0	7,321
> 6	15,141	0	0	5	15,146

## 7 DISCOVERY CREDIT RULES

**Discovery credit** is assigned to everybody involved in the discovery: in many cases the credit has to be shared.

**Priority** is attributed for a predominant contribution.

1. If a single Observer provides enough data for a Discovery, with a clear indication that these data belong to a single SSO, this implies full Discovery Credit.
2. If a single Observer provides enough data for a Discovery, without indication that they belong to the same SSO, the Discovery Credit is shared with the Orbit Computer submitting the Identification, the Observer has Priority.
3. If different Observers have contributed to the data for a Discovery, Credit is shared among them and among the Orbit Computer(s) performing the Identification(s).
4. The Discovery procedure is closed at the time in which enough data and computations have been submitted.
5. If one of the Observers has supplied data forming an Arc of Type  $\geq 2$ , clearly indicating that these data belong to the same SSO, then he/she has Priority.

6. If the data come from different Observers and all the Observers have supplied Arcs of Type 1, the Orbit Computer providing the Identification has Priority.
7. In more complicated cases the Observers and Orbit Computers contributing to the Discovery are listed in order of submission time, no one having Priority.
8. If some computations are performed by the Data Center, it can get the corresponding credit by using the date of publication in place of the date of submission.
9. Nobody can have credit for data and/or computations which were not public at the time.
10. If an object is already Discovered when the physical observations are submitted, Credit for the Discovery remains, Credit for the Discovery of a Comet goes to the Observer(s) supplying the critical physical data.
11. If the Observed Arc is not enough for a Discovery at the time the cometary nature is established, the Observer submitting the physical observations can get credit for Comet Discovery only if and when the Observed Arc becomes of Type 3.
12. The Observer supplying the critical data for cometary nature of the object has Priority for the Comet Discovery, although someone else may have Priority for the Discovery of the object.

## 8 NAMING RIGHTS RULES

**Naming Right** If there is one actor having either full Discovery Credit or Priority, he/she has the right to propose a name for the object discovered. The IAU Small Bodies Naming Committee (SBNC) will generally accept this name, unless it violates some of the IAU naming rules. If no one has Priority, the discoverers share the Naming Right, and they can propose a name by agreement; in case of disagreement the SBNC will decide.

**Naming Right for Comets** If and when there is enough evidence that a discovered SSO is a Comet, the comet name is composed by combining the names of all the actors having Discovery Credit, with the Observer having Priority for the Comet Discovery listed first.