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PRO-AM collaborations in Planetary Astronomy

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Abstract

Amateur contributions to professional publications have increased exponentially over the last decades in the field of Planetary Astronomy. Here we review the different domains of the field in which collaborations between professional and amateur astronomers are effective and regularly lead to scientific publications. We discuss the instruments, detectors, softwares and methodologies typically used by amateur astronomers to collect the scientific data in the different domains of interest.

1. Introduction

Astronomy is a unique scientific domain where amateurs and professionals collaborate significantly. Despite the exponential increase of amateur contributions to professional publications over the last decades (see Fig. 1), reviews describing the possible fields of PRO-AM collaborations in astronomy are very scarce. Here we aim at overcoming this deficiency in the field of planetary science and describe the different subfields in which PRO-AM collaborations are effective.

2. PRO-AM science

2.1 Monitoring of telluric planets

Amateur observations of the telluric planets Mercury, Venus and Mars are performed on a regular basis. Observations of Mercury are difficult due to the small maximum elongation from the Sun that reaches only 28° in the most favorable cases and maintains the planet always at low elevations from the horizon. Amateur observations of Venus and Mars provide useful

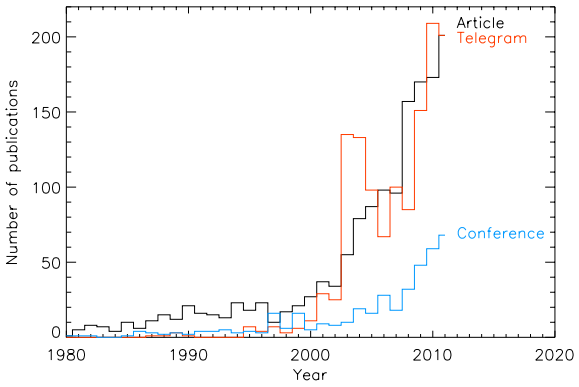

Figure 1: Statistics showing a significant increase of the publications involving amateur astronomers over the years.

information for understanding their respective atmospheres complementing data obtained from orbiters or large telescopes.

2.2 Interplanetary matter

Extraterrestrial fragments present in the interplanetary medium (mostly of asteroidal or cometary origin) may be revealed through bolides and fireballs, induced by the entry of meteoroids in the Earth's atmosphere, as well as by impacts of meteoroids on other Solar System bodies, e.g., giant planets or our Moon. These events are rare, hard to predict and often chaotic, setting a limit on the amount of data that professionals can acquire. The general public may nowadays play a role in the video-recording of bolides and fireballs (later leading to fair orbital determinations), as for instance illustrated with the Chelyabinsk event (Febru-

ary 2013, Russia). Amateurs have an important role in this field by helping the professional community in the scientific characterization of such phenomena, thus providing links between them and the properties of their parent bodies. The help of amateurs is also extremely precious to find meteorites on Earth.

2.3 Observations of asteroids

The asteroidal population contains nowadays more than 600,000 discovered objects. Most of them are located between Mars and Jupiter, in the so-called the Main Belt (MB). Approximately 10,000 objects are intersecting the orbits of telluric planets. These are the so-called Near-Earth Asteroids (NEAs). More than one thousand of these NEAs have Minimum Orbit Intersection Distance (MOID) below 0.05 AU with respect to Earth: these objects are called Potentially Hazardous Asteroids (PHAs). Two distinct groups of asteroids are also orbiting on trajectories similar to that of Jupiter 60° ahead and before the planet, i.e., the so-called Greeks and Trojans groups. Since a few decades, stellar occultations are used to access information about the asteroid shapes. In the 1990s, CCD technology replaced progressively the photographic searches, and photometric methods have been developed to derive the physical properties of the asteroids. In the following sections we introduce these techniques and propose how they can be used by amateurs in order to make real contributions in the field.

2.4 Outer planets

The giant planets Jupiter and Saturn are among the favorite targets for amateur astronomers offering outstanding science subjects where amateurs and professionals regularly collaborate. In fact, the amateur contribution is now regarded as an essential tool to study the atmospheres of Jupiter and Saturn for several reasons: (i) they provide the long-term global view able to support high-resolution regional observations from a spacecraft, (ii) amateurs observations predict the locations of features of interest for planning and targeting with professional level telescopes, (iii) visible observations provide the visible context for remote sensing at other wavelengths, (iv) identification of transient phenomena that could not be caught by pre-planned spacecraft observations, and (v) long term tracking of seasonal changes, or large-scale weather phenomena.

2.5 Comets

Comets, with their roughly round comae and their long tails, have been observed since ancient times. Thousands of them have nowadays been discovered. Amateur astronomers have always played an important role in the observation of comets. For a long time, they found most of the new comets; they presently contribute actively to discovery and imaging of comets. Besides, they still provide most of photometric and astrometric data. With the improvement of their instruments and the development of CCDs and digital cameras, they can provide accurate measurements for the different databases opened to the community.

2.6 Kuiper Belt Objects

There is a considerable lack of information about objects far out in our Solar System. One of the reasons is their large distance from the Sun and their size in general less than the size of the dwarf planet Pluto. Their physical properties can only be addressed by very sophisticated indirect techniques, such as infrared observations from space by the Herschel space telescope. Ground-based spectroscopy and photometry are other tools which may help. Observations of stellar occultations can provide some more insight into our outer Solar system, from defining the shapes of the bodies up to the detection of possible atmospheres.

2.7 Exoplanets: research and characterization

Extrasolar planets are an important field of planetary science since they provide a comparative view of our Solar System with other systems, from the solar neighborhood, to the center of the galaxy. Even if the level of details reached cannot be compared to planets of the Solar System, they permit to explore planet diversity in terms of planet's mass, radius, density, orbital period, eccentricity, obliquity, host star physical parameters, and planetary atmosphere properties and composition. The discovery and characterization of extrasolar planets is also providing elements to understand planet occurrence and to constrain planetary formation, migration and evolution models. Among the techniques accessible to amateurs, we can cite here the transit and microlensing methods. These two techniques are performed using a very wide range of instruments, including small-aperture photometric telescopes and amateurs telescopes.