Update on recent-past and near-future meteor shower outbursts on Earth and on Mars

Jérémie Vaubaillon[1], Rachel Soja[2], Lucie Maquet[3], Auriane Egal[1], Aswin Sekhar[4], Pavel Koten[5], Regina Rudawska[6], François Colas[1] and Bérénice Reffet[1]

[1] **IMCCE, Paris, Observatoire de Paris, 77 av. Denfert-Rochereau, 75014 Paris, France**
vaubaill@imcce.fr

[2] **University of Stuttgart, Institut für Raumfahrtsysteme, Pfaffenwaldring 29, Germany**
soja@irs.uni-stuttgart.de

[3] **LESIA, Paris Observatory, 5 pl. Jules Janssen, 92190 Meudon, France**
lucie.maquet@imcce.fr

[4] **Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland**
aswinsek@gmail.com

[5] **Astronomical Institute of the Academy of Sciences, Ondřejov Observatory, CZ-25165 Ondřejov, Czech Republic**
pavel.koten@asu.cas.cz

[6] **Comenius University, Mlynská dolina, 842 48 Bratislava, Slovakia**
rudawska@gmail.com

This work presents a brief reflection on the 2014 Camelopardalids and the Mars encounter with comet C/2013 A1 Siding Spring expected in October 2014. These two events were first thought to display an exceptional amount of meteors and later works showed that it would not be the case, at least in optical wavelength. Observation biases and low activity of the comet can explain those differences, but care must be taken when announcing any future meteor shower and close co-operation with other scientists is needed to strengthen the case.

1 Introduction

The year 2014 was rich in meteor shower announcements, with the Camelopardalids shower in May, as well as the encounter between comet C/2013 A1 Siding Spring and Mars in October. However, subsequent work and/or observations revealed significant differences between the expected events and the actual data/observations. Here, we reflect on those two particular events and the way meteor shower forecasting is performed today.

2 The 2014 Camelopardalids

The pioneering work by Jenniskens (2006, pp. 129 and 689), followed by Ye & Wiegert (2014), as well as our own study[1], showed that the dust emitted by comet 209P/LINEAR (2004 CB) during the 17th and the 19th century would intersect with the Earth on 24 May 2014. Because all the particles ejected during several decades would presumably make it to the Earth, the level of the shower was expected to be high, and announcements of ZHR up to 400 per hour were performed. Observation campaigns were organized in North America using optical detection and additionally in Europe using radio detection. However, not much was detected in optical, showing a level up to 15 meteors per hour. Radio detection showed more events (see Figure 1). Of course, the question arises as to why the forecasted event did not occur as expected.

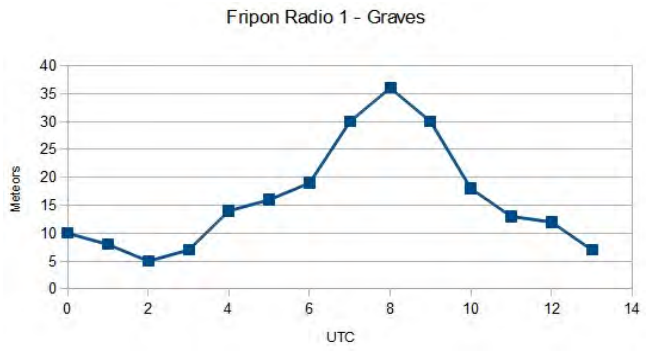

Figure 1 – Radio detection of the 2014 Camelopardalids from the FRIPON radio set-up (F. Colas, IMCCE).

A combination of different factors can be invoked. First of all,the comet is known to be extremely faint, probably not ejecting much dust both at the present as well as in the past

[1] http://www.imcce.fr/langues/en/ephemerides/phenomenes/meteor/DATABASE/209_LINEAR/2014/index.php?char=year&body=Earth&year=2014&shower=209_LINEAR

centuries. Such low activity is also typical for old comets that have not much dust left. Therefore, the size distribution of the particles for such comets might be shifted towards small sizes. All of this, combined with the fact that the velocity at the Earth is low (16 km/s) might explain why not much was observed in optical wavelength.

3 Comet C/2013 A1 Siding Spring at Mars

Comet C/2013 A1 Siding Spring was discovered in the early 2013 when it was further than 7 AU from the Sun. It appeared extremely bright for such a large distance, presumably explained by a massive nucleus and activity. Very soon it was realized that its orbit would put it very close to the planet Mars in October 2014. Consequently, a collision with the planet was considered, until further observations showed that it would not be the case. The shortest distance between the comet and the planet will be as short as 138.000 km on the 19th of October with a relative velocity of about 56 km/s. Given the number of spacecraft orbiting the planet, the need for an estimate of the amount of dust arriving into the atmosphere of Mars was urgent.

On the basis of the orbit and photometry measurement of the comet, two studies (Moorhead et al., 2014; Vaubaillon et al., 2014) showed that the cometary dust would enter the Martian atmosphere causing an extremely strong meteor shower, so much that the concept of a meteor hurricane was introduced by us. However, further studies (Farnocchia et al., 2014; Tricarico et al., 2014) showed that the nucleus was not as large as first thought, making the ejection velocity much smaller. As a result, it is today no longer expected that the dust emitted by the comet will actually make it to the Martian atmosphere. As a consequence, no meteor shower is expected at Mars on October 19th, 2014.

4 What have we learned?

From these two events, we can reflect on the way meteor shower forecasting is performed nowadays. After great success during the Leonids in the early 2000, it was shown that the activity of the comet in the past was important to predict the level of the shower. Present cases show that the statement remains true today! Links between the comet science and the meteor science should be tightened even more than ever. Photometry of the comet as well as the size distribution of the dust emitted by the nucleus (which is actually extremely hard to derive with optical observations) is a prior interest.

One of the difficulties is that the predicted level of a meteor shower is extremely sensitive to the value of the size distribution index, particularly from millimeter to centimeter size particles, for which we have usually no observation. The determination of the size distribution index for smaller particles should thus be measured for every comet potentially causing a meteor shower but this might not be enough.

This work has also showed that works considering the photometry information can be misleading when a comet is still at a very high heliocentric distance, where the dust is emitted mainly by CO_2 and the ejection velocity is lower than at smaller distances. As a consequence, dust staying close to the nucleus for a longer period of time makes the overall magnitude of the comet smaller than what it would be at smaller distance. For the same reason, it makes the [Afrho] parameter look higher than what it really is when the ejection is driven by water (Vaubaillon et al., 2005). It is advised that the production of meteor shower forecasting should wait for the comet to enter the zone where the dust is emitted by water mainly. However, this might sometimes conflict with the need for long-term planning of spacecraft operations. Compromise should be defined then.

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