The 2016 Quadrantids

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A report is presented on the observation of the Quadrantid shower recorded by RAMBO early January 2016. The data analysis – done by calculating the RZHR (Radar ZHR) – shows the complexity of the shower, in which the presence of multiple filaments is verified. A meteoroids mass profile is also made. Finally a comparison is made between the RAMBO radar data and the IMO visual data.

1 Introduction

The Quadrantid shower (10 QUA in the IAU Meteor Data Center[1]) is probably one of the greatest of all meteor showers that crosses the Earth's orbit each year, generating a visible increase in the number of "shooting stars" (Weiland, 2012). Its fame is lower than that for other meteor streams because of the adverse weather conditions of the first nights of the year. For this reason, radar observations take a greater importance since the radio systems are free from visibility conditions.

2 Quadrantids meteor shower

The shower duration is generally short - between 8.5 and 12 hours (Shelton, 1965; Hughes and Taylor, 1977; Baggaley, 1979) – and this is probably due to its very recent origin: the first sighting seems to have been around 1835. Only in 1862 there is a first document that mentions "shooting stars of January". In 1864 Alexander Herschel identifies the radiant point near the star c Quadrantis Muralis (coordinates $\alpha = 230°$, $\delta = +49°$): the name "Quadrantids" comes from this. Since 1929, following the redefinition of the system of constellations accomplished by the International Astronomical Union, the constellation was abolished and now the radiant lies in Boötes. Some astronomers call this shower the "Bootids" (Jenniskens, 2006).

A lot has been done to find its parent body. Since 2003, the year of the discovery of the asteroid *2003 EH$_1$*, numerical simulations tend to discard a cometary origin and now it is assumed that this stream of debris may indeed have been generated by that asteroid (Porubcan and Kornos, 2005). Until now astronomers are not sure that this parent body is actually a "classically understood" asteroid or instead it is the core of an extinct comet, the *C/1490 Y$_1$*.

The orbit of the Quadrantids is much tilted ($I > 70°$). The particles' velocity relative to the Earth (41 Km/h) is a medium value in the meteor velocity range. Different filaments were detected within this stream (Jenniskens, 2006).

3 The 2016 observation

For 2016 the forecast[2] of its peak was January, 4 at $8^h\,00^m$ ($\lambda_\odot = 283°.18$).

The observations of the Quadrantids performed by RAMBO (Radar Astrofilo Meteorico Bolognese) - built by the Meteor Research Group[3] of Associazione Astrofili Bolognesi[4] show that the phenomenon started when the radiant is decreasing in the afternoon of January 3 (*Figure 1*). It drops to below 10° of altitude for six hours and then starts to rise in elevation, at about 23^h UT, when the phenomenon is already in full swing. At about 6^h UT on January 4, it gets at its maximum before decreasing again.

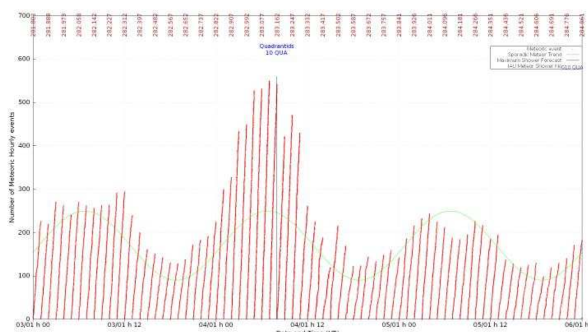

Figure 1 – 2016 Quadrantids Hourly Rate: green line represent the sporadic meteors trend.

The radiant culminates at 8^h UT. Its descending elevation did not allow us to record two peaks at 9^h UT and 15^h UT on January 4.

4 Data analysis

The data analysis shows the presence of at least three filaments, two very close and one spaced of about 8 hours from the first peak.

The statistical analysis and the calculation (McKinley, 1961; Sandri, 2003) of the RZHR (*Figure 2*) – performed with *RZHR3*, a software program written in Python

[1] IAU MDC, http://www.ta3.sk/IAUC22DB/MDC2007/

[2] Data taken from the *IMO 2016 Shower Calendar*, pages 4-5.

[3] The RAMBO/Meteor Research Group has an email address (rambometeorgroup@gmail.com) and a web site (http://www.ramboms.com) - in Italian and in English - where all the data and publication are collected.

[4] AAB web site: http://www.associazioneastrofilibolognesi.com

version 3 by the author (*Figure 7*) – highlights more effectively the hourly rate trend corrected for the height of the radiant point and for the sporadic meteors contribution.

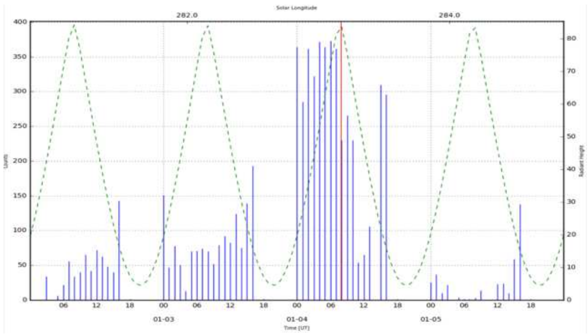

Figure 2 – Radar ZHR (RZHR): blue lines are RZHR values, the red line is the forecasted peak and the green dotted line is the radiant point position.

In addition to the hourly rate, the evidence of the stream's complexity is illustrated by the meteoroids mass profile. *Figure 3* shows the trend of the meteor echoes duration. As the echo duration is proportional to the meteoroid mass, I can obtain an indication on the mass variation during the meteoric shower. Although the data are not related, I can see that this trend is perfectly comparable with the hourly rate profile.

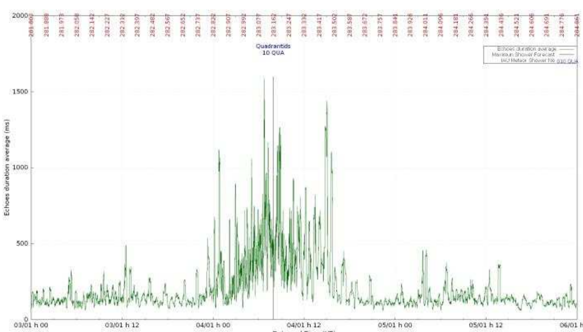

Figure 3 – Meteoroids mass variation in the echoes analysis.

I can say that the 2016 Quadrantids shower recorded by RAMBO has seen a succession of three peaks: two very close at solar longitude of 283.12 (6^h 58^m UT) and 283.19 (8^h 37^m UT) and a third at 283.45 (14^h 44^m UT).

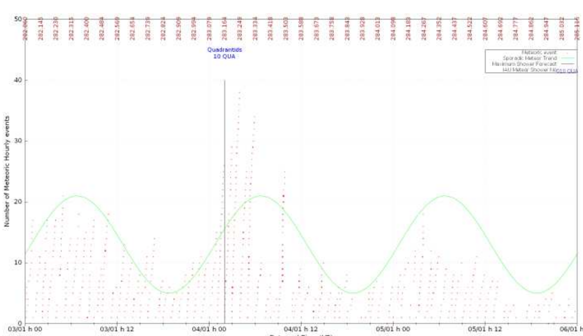

Figure 4 – 2015 Quadrantids Hourly Rate.

5 Data comparison

RAMBO data

The 2015 RAMBO registration (*Figure 4*), accomplished with a less reliable version, and the RZHR calculation (*Figure 5*) shows a trend similar to those of 2016: a maximum composed of two closely spaced peaks and an extra peak about 8 hours later.

IMO data

It may be interesting to compare RAMBO radar data with the IMO visual data.

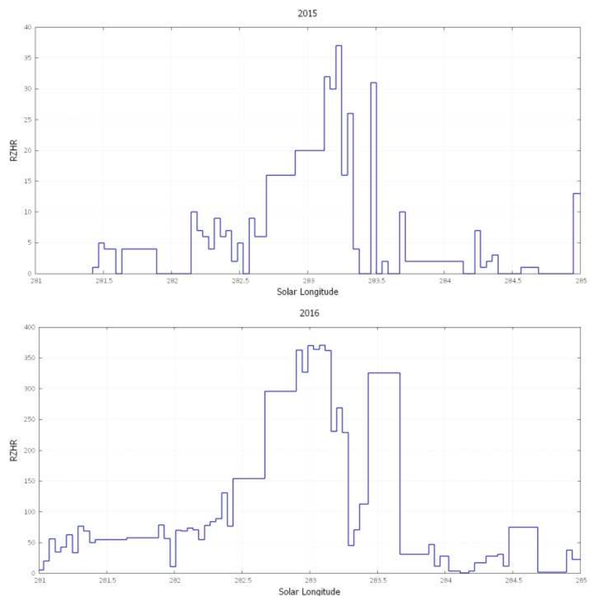

Figure 5 – 2015 (top) and 2016 (bottom) RZHR comparison.

Table 1 – Peaks of the Quadrantids from visual and radar observations.

Year	λ⊙ peak	Source
2008	283.28	*IMO*
2009	283.08	*IMO*
	283.17	*IMO*
2011	283.23	*IMO*
	283.45	*IMO*
2012	283.07	*IMO*
	283.11	*IMO*
	283.62	*IMO*
2013	283.45	*IMO*
	283.62	*IMO*
2014	283.18	*IMO*
2015	283.22	*RAMBO*
	283.30	*RAMBO*
	283.50	*RAMBO*
2016	282.88	*IMO*
	283.05	*IMO*
	283.20	*IMO*
	283.12	*RAMBO*
	283.19	*RAMBO*
	283.45	*RAMBO*

In *Table 1*, I summarize the solar longitude of the peaks observed by IMO[5] and by RAMBO. *Figure 6* is a graphical representation of *Table 1*. It is clear that the radio data displays the same time pattern.

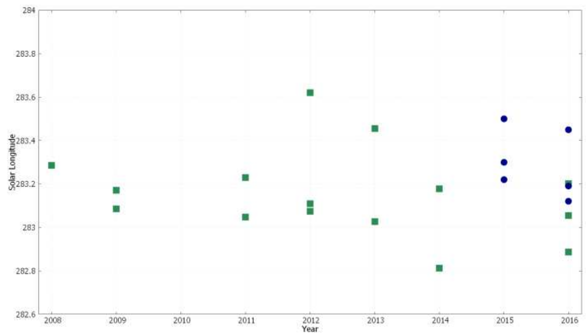

Figure 6 – Solar longitudes of the Quadrantids' peaks in 2008–2016 from visual observations (IMO, green squares) and 2015–2016 RAMBO data (blue dots).

6 Future development

Looking at the IMO data represented in *Figure 6*, It looks as if a few years are not present. This may be due to unfavorable night weather conditions (widespread cloud cover, rain, snow, etc.) or the presence of light disturbances (the Moon in its various phases, light pollution). These are the limits of visual observation. On the other hand, the strength of visual observations is the possibility of observing the phenomenon on a global level.

Radar observations do not suffer from weather conditions or the presence of light pollution and they can be made throughout the day, but they need a well-built and calibrated system of registration and a subsequent statistical analysis to eliminate the part of sporadic meteors.

This is RAMBO: a system built and well calibrated that works seven days a week, twenty-four hours a day. For the moment it is limited to a single observing station (the seat of our association in Bologna) and the necessity to have the radiant point above the horizon.

These problems can be overcome if, as in visual observing, a global radio network is created. As research group, we hope for the future that other similar setups could be installed all around the world, in order to achieve a global coverage.

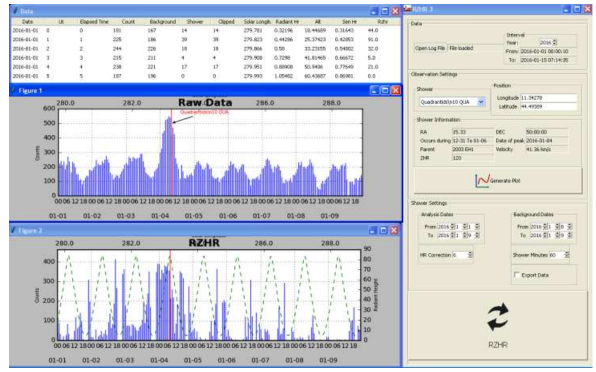

Figure 7 – *RZHR3* screenshot.

References

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[5] IMO – ZHR Live Graphs, http://www.imo.net/zhr