Identification of two new meteor showers: #797 EGR and #798 ACD

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The Brazilian Meteor Observation Network - BRAMON - reports the discovery of two new meteor showers, initially observed after a search in its own database. For the meteor shower # 797 EGR, it is listed one meteor in 2014, eight meteors in 2015 and three meteors in 2016 (two are in the BRAMON database and one in the EDMOND database), occurring between solar longitudes of 77° and 89°. The average radiant position is in right ascension of 342.3° and declination of -51.39°. For the meteor shower # 798 ACD, it is listed two meteors in 2014 (one meteor in the BRAMON database and one meteor in the EDMOND database), eleven meteors in 2015 (ten meteors in the BRAMON database and one meteor in the base of EDMOND data), six meteors in 2016 and four meteors in 2017. occurring between solar longitudes of 120.7° and 139.7°. The average radiant position is in right ascension of 68.82° and declination of -38.15°.

1 Introduction

BRAMON is a meteor-monitoring network that was created in 2014 to record and study meteors over Brazil, which is in a privileged position in the southern hemisphere (Amaral et al., in press), as well as to provide more detailed information about high-luminosity bolides and other meteorites (Zurita et al., 2019). The result of this effort resulted in the production of a database made available together with the EDMOND database (Amaral et al., 2018; EDMOND, 2018).

2 New showers

A video showing the evolution of the radiants of the meteors paired by BRAMON between the years 2014 and 2015 was created as a first analysis approach. It was observed, in both years, an unexpected concentration of meteors in the direction of the Grus constellation, always in mid-June. During the video analysis process, it was also noticed a meteor grouping that happened in the Caecum constellation repeating at the beginning of August. The calculations were performed following the methodology proposed by Drummond (1981), showing the existence of two small outbursts to be called epsilon Gruids (EGR) e August Caelids (ACD).

3 Methodology

For the identification of a new shower, it was adopted that a meteor cluster must have at least six members whose orbits have the criterion of similarity smaller than 0.105 in relation to the group average orbit. The similarity criterion was initially defined by Southworth & Hawkins (1963) in which the similarity between two orbits is defined as the distance between two points in a five-dimensional space, described by their conventional orbital parameters: q (perihelion distance), e (eccentricity), i (inclination), ω (perihelion argument) and Ω (longitude of the ascending node), as shown in Equation 1.

\[
[D_{ab}]^2 = (e_1 - e_2)^2 + (q_1 - q_2)^2 + \left(2\sin\left(\frac{I_{12}}{2}\right)\right)^2 + \left(\frac{e_1 - e_2}{2}\right)^2 \left(2\sin\left(\frac{\Omega_1}{2}\right)\right)
\]

(1)

where, suffix 1 and 2 refer to the two orbits to be compared, \(I_{12}\) is the angle between the planes of the two orbits, and \(\Omega_1\) is the angle between their respective perihelion points. These angles are defined in Equations 2 and 3, and Γ is defined in Equation 4.

\[
I_{21} = \arccos\left[\cos(i_1)\cos(i_2) + \sin(i_1)\sin(i_2)\cos(\Omega_2 - \Omega_1)\right]
\]

(2)
\[ \Pi_{21} = \omega_2 - \omega_1 + 2\arcsin \left( \cos \left( \frac{\omega_2 - \omega_1}{2} \right) \sin \left( \frac{\Omega_2 - \Omega_1}{2} \right) \sec \frac{i_2}{2} \right) \]

\[ \Gamma = \begin{cases} +1, & |\Omega_2 - \Omega_1| \leq 180^\circ \\ -1, & |\Omega_2 - \Omega_1| > 180^\circ \end{cases} \]

Drummond (1981), proposed some modifications in the dissimilarity criterion of Southworth & Hawkins (1963), resulting in D-Drummond Criterion (DD), whose definition is shown in Equation 5.

\[ [D_D]^2 = \left( \frac{e_2 - e_1}{e_2 + e_1} \right)^2 + \left( \frac{q_2 - q_1}{q_2 + q_1} \right)^2 + \left( \frac{\Omega_1}{180^\circ} \right)^2 + \left( \frac{\theta_{21}}{180^\circ} \right)^2 \]

where, \( I_{31} \) is the angle between the two orbital planes defined in Equation 2, and \( \theta_{21} \) is the angle between the perihelion points of each orbit, defined in Equation 6.

\[ \theta_{21} = \arccos[\sin(\beta_1) \sin(\beta_2) + \cos(\beta_1) \cos(\beta_2) \cos(\lambda_2 - \lambda_1)] \]

where, \( \lambda \) and \( \beta \) are respectively the longitude and ecliptic latitude of the perihelion defined in Equations 7 and 8.

\[ \lambda = \Omega + \arctan(\cos(i) \tan(\omega)) \]

\[ \beta = \arcsin(\sin(i) \sin(\omega)) \]

Subsequently, other definitions were proposed by Jopek (1993) and by Valsecchi, Jopek & Froeschlé (1999). However, for the validation of these showers it was used the criterion defined by Drummond (1981).

### 3.1 Identification of clusters

The identification of the meteors was done using a visual approach. The epsilon Gruid meteors were initially identified in a visual analysis of an animation showing the radiant position of the recorded meteors identified during the first two years of BRAMON operation. The animation was composed of 731 frames, one for each night between 01/01/2014 and 12/31/2015. Each frame was generated using the UFOOrbit software (Sonotaco, 2009) and shows a celestial map with the radiant of all the meteors recorded in the previous 15 nights, in addition to the position of each meteor shower officially known that is active at the time. Observing the resulting animation, a concentration of supposedly "sporadic" meteors was observed between June 7 and 19, next to the Grus Constellation. Using the UFOOrbit software (Sonotaco, 2009), the orbital parameters of these meteors were extracted. They were numbered 19, with seven in the year 2014 and twelve in the year 2015. The August Caelids meteors were perceived during the use of the UFORadiant software (Sonotaco, 2009) while analyzing the BRAMON database in search of new meteors candidates for the epsilon Gruids shower. The orbital parameters of eight meteors were extracted, seven of them occurred in 2015 and one in 2016.

### 3.2 Dissimilarity test

At first, it was obtained the average orbit of the meteors in initial cluster. Then, the dissimilarity between this average orbit and each meteor in the cluster was calculated using the D Criterion (Drummond, 1981). All meteors of the cluster with D Criterion smaller than 0.105 were maintained while the others were discarded. A new average orbit was calculated for the remaining meteors and dissimilarity was calculated again for each member of the new cluster. The process was repeated until the number of members of the cluster stabilized. As a minimum limit of six meteors in two distinct years to was achieved, the cluster can be reported as a potential annual shower. Lastly, the dissimilarity test was used in a search for a parental body of the proposed showers. The dissimilarity between the average orbit of these showers and the objects of the Comet and near-Earth asteroid databases was calculated as done by Šekon et al., 2013.

### 3.3 Nomenclature

Based on a proposal from Jenniskens (2008), a meteor shower name is defined by the constellation that has the star closest to its radiant, using the possessive form of Latin followed by the suffix id or ids. If greater precision is required, the name should include the Greek letter from the name of the brightest star closest to the radiant. One can opt to add the name of the month of the shower peak to its name to distinguish it from other showers in the same constellation. Following these criteria, the names defined for the showers were epsilon Gruids, for its radiant being next to the epsilon Gruid star, and August Caelids, for their radiant being in the Caelum constellation and its maximum occurring in the month of August. The acronyms must be unique, containing three letters and approaching the spelling of the name of the shower. For epsilon Gruids, the acronym EGR was defined and the 797 number was designated by the Meteor Data Center. For the August Caelids, ACD along with the 798 number.

### 4 Results

#### 4.1 EGR - epsilon Gruids

After the initial report to the IAU, new meteors linked to the shower were registered by BRAMON, maintaining the orbital dissimilarity criterion. The records were distributed as follows: 2014 - one meteor; 2015 - eight meteors; 2016 - three meteors. The meteors of the Grus constellation cluster occurred from June 7 to 19 with an average solar longitude of 81.37° (J2000.0). The mean
radiant position of shower #797 EGR was determined to be under the point with R.A. = 342.28° and Dec = -51.39°. The average geocentric velocity of the meteors is 52.86 km/s, the mean daily motion of the radiant was estimated as ΔR.A. = 1.1°/day and ΔDec = 0.0°/day. No parental body candidates were found using the dissimilarity test between the average orbit of the shower #797 EGR and the objects in the Comet and near-Earth asteroid databases. Details of the shower orbital parameters can be seen in Table 1 and the distribution of the meteors around the radiant is shown in Figure 1.

![Figure 1](image1.png)

Figure 1. Distribution of meteors (with geocentric velocities) around the mean position of the epsilon Gruidae radiant.

### 4.2 ACD - August Caelids

Again, after the initial report to the IAU, new meteors registered by BRAMON were added to the shower, maintaining the criterion of orbital dissimilarity. The records were distributed as follows: 2014 - one meteor; 2015 - eleven meteors; 2016 - six meteors; 2017 - four meteors. The meteors of the Caelum constellation cluster occurred from July 23 to August 12, with average solar longitude of 131.38° (J2000.0). The average radiant position of shower #798 ACD was determined to be under the point with R.A. = 68.82° and Dec = -38.15°. The average geocentric velocity of the meteors is 44.87 km/s, the mean daily motion of the radiant was estimated as ΔR.A. = 0.54°/day and ΔDec = 0.13°/day. Again, no parental body candidates were found using the dissimilarity test between the average orbit of the shower #798 ACD and the objects in the Comet and near-Earth asteroid databases. Details of the orbital parameters can be seen in Table 2 and the distribution of the meteors around the radiant is shown in Figure 2.

![Figure 2](image2.png)

Figure 2. Distribution of meteors (with geocentric velocities) around the mean position of the August Caelids radiant.

### Table 1 – List of the Meteors (#797 EGR)

<table>
<thead>
<tr>
<th>Meteor</th>
<th>λ⊙</th>
<th>R.A</th>
<th>DE</th>
<th>Vg</th>
<th>a</th>
<th>e</th>
<th>q</th>
<th>Peri</th>
<th>Node</th>
<th>i</th>
<th>DD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20140613_081309</td>
<td>82.06</td>
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<td>-53.24</td>
<td>52.20</td>
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<td>7.99</td>
<td>0.91</td>
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<td>257.90</td>
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<td>-</td>
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<td>107.48</td>
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<td><strong>Means</strong></td>
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<td>0.73</td>
<td>66.60</td>
<td>261.43</td>
<td>99.50</td>
<td>0.05</td>
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</tbody>
</table>

* Meteor from the EDMOND database

### Table 2 – List of the Meteors (#798 ACD)

<table>
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<tr>
<th>Meteor</th>
<th>λ⊙</th>
<th>R.A</th>
<th>DE</th>
<th>Vg</th>
<th>a</th>
<th>e</th>
<th>q</th>
<th>Peri</th>
<th>Node</th>
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<td>-</td>
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<td>343.6</td>
<td>310.5</td>
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</table>
5 Conclusion

The discovery of two meteor showers in such a short time of operation of such a new meteor monitoring network demonstrates the potential of showers yet to be unveiled on the southern hemisphere. This potential can be exploited by BRAMON due to the privileged position of its stations distributed throughout Brazil and to the large number of operators integrating the network. In addition, the association of BRAMON with other initiatives such as the SONEAR Observatory can help on the search for parental bodies associated with the newly confirmed showers and future finds.

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