Spacecraft risk posed by the 2016 Perseid outburst

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Introduction

The Perseids are one of the more prolific annual showers, known for high rates and for producing bright meteors. Outbursts of this shower have been noted in the 1860s, the early 1990s, 2004, and 2009, with the 1993 outburst being especially active (peak ZHR above 300). The 1993 Perseids also affected the space-faring nations, as the launch of the STS-51 mission was delayed by NASA until after the shower maximum due to an inability to predict the shower intensity, and the ESA telecommunications satellite Olympus suffered a mission-ending anomaly attributed to a static discharge caused by a Perseid impact [1]. Rates were again high (peak ZHR around 200) in 2009, when the NASA/USGS imaging satellite Landsat-5 experienced a gyro anomaly just before the shower peak; however in this case, the satellite was recovered and normal operations resumed one week later [2]. It is interesting to note that both spacecraft anomalies were not what is typically expected from meteoroid strikes, i.e., physical damage or an attitude displacement due to transfer of momentum. It would appear that the very fast Perseids (59 km s^{-1}) have a marked ability to produce plasma upon impact, which can then serve as a conductive path for discharge currents. The shower is expected to outburst again in 2016, and we present the results from the MSFC Meteoroid Stream Model [4], which predicts enhanced activity on a level similar to that of 2009 as the Earth passes through several debris trails on the night of August 11-12 (UT). We then compare our results to those of other modelers.

The 2016 Perseids

In order to evaluate the intensity of the 2016 Perseid shower, 13.5 million particles having masses between 1 μg and 1 kg were ejected from comet 109P/Swift-Tuttle with speeds according to Jones [3]. Fifteen revolutions of the comet (58 – 1862 CE) were modeled and particle orbits with nodal crossings within 0.01 AU of Earth's orbit selected for analysis. The main contributors to Perseid activity in 2016 are particles ejected in 1862 (1 rev), 1479 (4 rev), 1079 (7 rev), and 441 (12 rev), and a comparison of the 2016 results to model runs and shower observations for previous years suggests that this year's Perseid outburst will exhibit at least two maxima [figure 1]. The first and strongest peak (ZHR ~210) will occur just past midnight UTC on August 12, and is predominantly caused by encounters with particles belonging to the 1 and 4 rev streams. There is also a contribution by the 7 rev stream at the tail end of this activity spike, around 4 UTC.

The second peak roughly coincides with the time of the traditional maximum, enhanced by 12 rev material. It is expected that this will increase the peak ZHR to about 130, which is 30-40% greater than normal. Factoring in the first activity peak, the 2016 Perseids should exhibit above average activity for over half a day, from late UTC on August 11 to just past the middle of August 12.

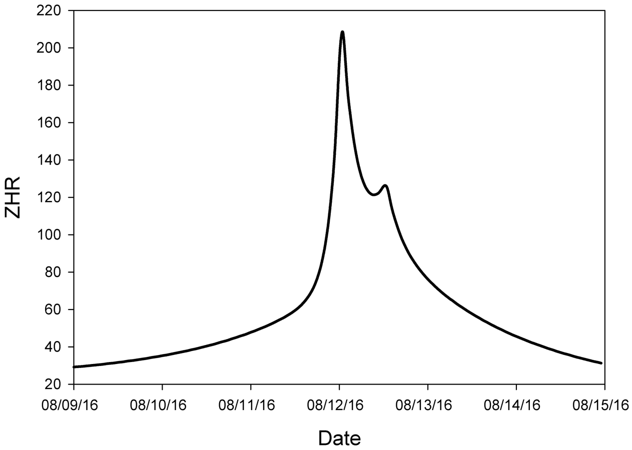

Figure 1. 2016 Perseid activity profile as forecast by the MSFC model.

Risk to spacecraft

The forecast level of Perseid activity is between that of the 1993 and 2009 outbursts that saw gyro related anomalies near the times of maximum. However, it should be pointed out that the projected kinetic energy weighted Perseid flux at the time of the strongest maximum is only increased by 50% above that of the normal sporadic background, suggesting that there is little need for concern regarding physical damage to spacecraft. If the anomalies experienced during previous outbursts are indeed caused by Perseids, the suggested dependency of plasma production potential on $v^{3.5}$ will result in a critical particle mass well below that of physical damage, which implies an anomaly flux one or two magnitudes higher than the kinetic energy value. Spaceflight programs are encouraged to determine if there are any conductive paths to the outside of their vehicle, monitor their spacecraft during the time of the outburst, and have recovery plans in place in case they are needed.

References

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