THE LEONIDS AND THE COMET:- HISTORY AND THEORY

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1. Introduction

The recorded history of the appearances of spectacular Leonid displays have been discussed for example in Yeomans (1981) and also in other papers at this meeting. The similarity in the orbits and that of comet 55P/Tempel-Tuttle is a strong indication that they are related. Further proof of this comes from the fact that the most spectacular displays associated with this stream are seen at time intervals that are multiples of the orbital period of the comet. The explanation for the occurrence of storms is thus that a well populated group of meteoroids are located close to the parent comet. Such a grouping of meteoroids would be formed if the comet were still active, not an unreasonable assumption. However, this raises an other question, namely why have the older of these meteoroids ejected perhaps several thousand years ago, not spread about the orbit. Standard models (*eg* Williams 1992) suggest that in 20 or so orbits meteoroids will have spread all the way from being close to the comet to being at the opposite point of the orbit. Hence, meteors in similar numbers should be seen every November coming from the Leonid stream. This is not the case, the average zenithal hourly rate of meteors in non-storm years being less than 10 as opposed to several thousand during a storm.

2. The Removal of Stream Meteoroids

There are only two ways in which it would not be possible for leonid showers to be spectacular in most years, either the stream is so young that meteoroids have not spread to all parts of the orbit, or the meteoroids have been removed from most of the orbit. Since we have argued that the first option is not feasible, we are left only with the second alternative. We should remember that within this context, removal means simply modifying the orbit of the meteoroids to an extent that their orbits no longer intersect that of the Earth. this does not require a major perturbation and it is a change that might easily be generated by a close passage of a major planet.

A simple discussion will indicate that the planet Uranus can be responsible for clearing out the Leonid meteoroids. Further discussion of this topic can be found in Williams (1997). The mean radius of the Uranian orbit is 19.2 AU. The ascending node of the orbit of comet 55P/Tempel-Tuttle is at a heliocentric distance of 18.2 AU while the aphelion distance is 19.7 AU. It takes the comet 6 years to move from aphelion to the node and thus it takes about 12 years from when it is first further than 18.2 AU from the Sun to being within that distance again. Though the motion is retrograde, the relative speed of the comet and Uranus throughout this interval is under 10 kms^{-1}. Hence, it is reasonable to assume that meteoroids on this arc will be lost.

Further, Uranus and the comet are moving very close to a 5 : 2 mean motion commensurability. Hence, the geometry repeats every two orbits of Uranus. Every 186 years, two gaps corresponding to 12 years worth of meteors each are swept out, while any remaining locations always miss Uranus. It is a simple calculation to determine that the locality close to the comet currently misses Uranus. Hence, at the present time, we would expect meteoroids close to the parent to survive while those not close are lost.In other words we would expect meteor storms whenever the comet is close to Earth, but not otherwise, exactly as is observed.

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Note that in under 200 years time, because the commensurability is not perfect, the positions will have drifted and close encounters of Uranus with the comet become possible. At that time, the phenomenon of Leonid storms will be at an end, we live in an interesting time!

References

Williams I.P. (1992) The Dynamics of Meteoroid Streams *in Chaos, Resonance and Collective Dynamical Phenomina in the Solar System*, Ed Ferras-Mello S., Kluwer Acad. Pub., Dordrecht

Williams I.P. (1997) *Mon.Not.R.astr.Soc.*,(in Press)

Yeomans D.K. (1981) Comet Tempel-Tuttle and the Leonid Meteors *Icarus*,**47**, 492-499

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