THE DYNAMICS OF METEOROID STREAMS

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SUMMARY

Meteor showers, seen at regular and frequent intervals on Earth, are caused by the interaction of meteoroids (that is small dust grains) in a coherent stream, all moving on similar heliocentric orbits, with the atmosphere of the Earth. The formation and dynamical evolution of such streams is discussed and techniques, including numerical integration, for following their evolution is described. In some cases the evolution is very critically dependent on initial conditions and the evolution may be chaotic. In addition to general considerations, some specific streams, all with individual areas of interest, will be discussed.

1. INTRODUCTION

Numerous meteors, or shooting stars, can be seen on any clear night. Regular observation will however show that the appearance of the meteors is not totally random but that above a random or sporadic background, many meteors can be seen at certain times of the year, the first few days of January or the second week in August being good examples. At these periods of high activity, it will also be evident that there is a pattern to the spatial distribution of the meteors with many of the trails appearing to originate from a single point on the sky, called the radiant. This point is however variable from shower to shower and it is the custom to name the shower of high activity after the constellation in which the radiant is located. Thus the high activity period in the second week of August is called the Perseid meteor shower. The explanation for these observed phenomenae is that in interplanetary space there exists sets, or
streams, of small solid particles which we shall call meteoroids moving on nearly identical heliocentric orbits and that a meteor shower is seen whenever the Earth passes through such a stream, the visible meteor being caused by the meteoroid burning up in the upper atmosphere. The Earth must, by definition of the node, pass through each stream at the node of the stream and if there is no dynamical evolution of the stream, the shower will be seen at exactly the same time each year. Conversely, any observed change in the time of appearance of the shower maximum gives a very good determination for the rate of retrogression or progression of the node.

The data for the main known meteor showers is given in Table 1. Here, Z.H.R stands for the Zenith Hour Rate, that is the number of meteors that would have been seen per hour if the radiant had been at the Zenith and seeing conditions perfect. Naturally the number of meteors actually seen is somewhat less than this number. However, there are now agreed procedures for dealing with the correction for a non-zenith radiant and so the Z.H.R does give a reliable guide to the relative meteoroid population densities in the various streams.

The possible association of comets and meteoroid streams appears to have first been suggested by G.V. Schaparelli in 1866 (see Oliver 1925 for this and other references to early work on meteors and meteoroid streams). This suggestion of Schapparelli was based on the similarity of the orbits of the Perseid stream and comet 1862ii (now known as periodic comet Swift-Tuttle) and of the Leonid stream with comet 1866i (now called periodic comet Tempel-Tuttle). The activities of comet Biela must also have played an important part in the formulation of the comet-meteoroid stream hypothesis. In 1832, comet Biela appeared as a perfectly normal comet with a period of about six and a half years. At its next predicted return in 1839, observing conditions...