Oort-type reservoir, whether comets are concentrated or extended objects, and the material constitution of comets, must be taken together into a particular received picture, whereas of course these questions are in fact separable.

For example, the second of the three lines of evidence adduced by Wallis is directed to the icy-conglomerate model and this does not seem to be very diagnostic with regard to the other questions since cosmically abundant volatiles are likely to play a large part in almost any acceptable mechanism we can imagine for the creation of comets. In any case my communication[3] stated explicitly that the spectroscopic evidence seemed to support this constitution very well.

The other two lines of evidence put forward by Wallis[1] contain some questions which may require answers from the proponents of all points of view, but of a more detailed nature than it is suitable to pursue here. It may however be worthwhile to mention the danger of circular argument. To speak of perturbations of the orbit of a comet may already be to assume just what is in question, namely that there is a gravitating solid body there to have an unperturbed orbit in the first place. Similarly there is no need to demand release speeds of the order of 10 km/s in order to fill a 10^7 km coma unless it is assumed that the release takes place from some central body.

Since it is topical, it may be mentioned in conclusion that some at least of the difficulties discussed by Zolotov[4] and recently quoted by Wilkerson and Worden[5], in explaining the Tunguska Event as due to the impact of a solid body, may be mitigated if a looser structure can be assumed.

I am, Gentlemen,

Yours faithfully,

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New Saturnian Satellites?

GENTLEMEN,—

It has always seemed strange to me that astronomers have spoken of the Cassini Division in Saturn's rings as a resonance phenomenon. The theory has it that the gap was cleared by Mimas, for which the 2:1 resonance position lies close to one edge of the Cassini gap. Yet it is well known that secular perturbations do not behave in this fashion. For example, the

Kirkwood Gaps in the asteroid belt cannot be explained in this way, even the gap in 2:1 resonance with Jupiter[1,2], since the perturbations simply do not make it less probable for an orbit to occupy the gap. (The explanation of the Kirkwood Gaps is still considered to be unknown.)

Quite the contrary situation usually exists: if one looks at the resonance locations for the solar system's satellites, one often finds there another satellite. Seven of the satellites are in a 2:1 resonance. In other words, it is our experience (the asteroid belt excepted) that the 2:1 resonance position is often a *preferred* location for matter, rather than an *avoided* one.

It might be objected that these satellites are not in an exact 2:1 resonance. However, the width of the 2:1 Kirkwood Gap is about 0·1 a.u., or about 3 per cent of its solar distance. This means that asteroids having periods within ± 2 per cent of the exact resonance are all deficient in number. Similarly, the width of the Cassini Division in Saturn's rings is 2·3 per cent of its distance from Saturn, corresponding to a period range of $\pm 1{\cdot}7$ per cent about the critical period. This reflects the fact that, dynamically, nothing special happens at exact resonance which has not already started to happen in the approximate neighbourhood of exact resonance.

Therefore, when we find Io within 0·6 per cent, Europa within 1·2 per cent, Mimas within 0·2 per cent, and Enceladus within 0·1 per cent of the corresponding exact resonant periods, we see that it is fair to describe them as "resonant". Gravitationally, approximate resonance means that the main perturbations at conjunction occur in nearly the same part of the orbit, revolution after revolution, for a very long time. In a non-resonant situation, the perturbations occur in a pseudo-random fashion around the orbit. There is a gradual transition from the one case to the other as one recedes from a resonant situation.

In so far as this pertains to the Cassini Division, it leads to the interesting speculation that the gap actually marks the location of another Saturnian satellite, too small to be seen as a separate body in the midst of the bright rings (except perhaps when the rings are edge on, when "ring knots" of a few hundred kilometres' diameter are often seen). It requires no equations to understand how the gap can be cleared by collisional removal in the 1:1 resonance case; and apparently even a satellite of Mimas's size or a little smaller in the gap could have escaped direct optical discovery up to now.

As the search for Saturn X, XI, etc., intensifies during the coming edge-on apparition of the rings and the *Pioneer* spacecraft encounter with Saturn, it might be helpful in the determination of orbits of possible new satellites to remember that they don't necessarily have to have orbital radii exterior to the outer ring. Indeed, each major ring division may mark a new satellite orbit.

I am, Gentlemen,

Yours faithfully,

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1978 June 29

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