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TO WHOM IT MAY CONCERN

RE: REPORT ON THE DOCTORAL THESIS OF LUKÁŠ SHRBENÝ

GENERAL POINTS

1) The thesis is well written, and well structured. An interesting dataset is developed and discussed in detail. In addition, the candidate includes a very nice and thorough introduction to the subject area and review of the theory.
2) A minor point on the text: in the great majority of cases the English is very good, but there are a relatively large number of typos, most of which should have been caught by the word processor.
3) Only one other general comment. Throughout, the candidate presents data for the meteors in this study, but although literature data are mentioned, there are rather few comparisons to the literature data (Fig. 3.42 is an exception). For instance, Fig. 3.40 is a very nice plot, which shows quite dramatically how fireball type varies between these different streams, essentially spanning the complete range. But it would be very nice to see accurate literature data added to this, if it exists – it would certainly strengthen subsequent discussion. And if in most cases the data doesn't exist then clarify that point – ie. say that it doesn't exist – and certainly shout louder about what a unique dataset this is!

SPECIFIC POINTS

1) P.4-5. I am interested in the classification of fireball types. Ceplecha and McCrosky (1976) defined the categories, but is there a more recent analysis of this, taking into the hugely improved statistics provided by MORP and EN? I'm wondering - if we combine all the PN, MORP, and EN data - would we see more structure in a plot such as Ceplecha and McCrosky (1976) Figure 1, where PE was plotted for a relatively small number of cases? For instance, from a meteoritics point of view. it's surprising that we can't more closely define iron meteoroids: given the fact that they comprise 5% of meteorite falls we should see them in this type of dataset. I'm not suggesting it forms part of this thesis, but if it hasn't been done already then it might be an interesting study.
2) P.28. On the link between a meteor shower and a specific parent comet. Is this via the D discriminant? If so, could you comment on the work of J. D. Drummond (e.g. 2000, Icarus 146, 453-475)? My understanding from this is that the association between a number of meteor streams and accepted parent comets is actually weaker than that for some proposed (and much more controversial) asteroidal debris streams.
3) P.38 (and P.86-88). The Geminids have experienced this high heating, which may have caused alteration (and local sintering and/or low-level metamorphism). I would expect the degree of alteration to be relatively heterogeneous (because if I understand correctly, it should vary significantly with depth). Therefore, it seems possible at least

that we would see more variability in composition / material properties / strength in the Geminids than in other meteor streams. From subsequent discussion (P.86-88) this does appear to be the case: from Fig 3.33 it is apparent that the Geminids (together with the Leonids) have the largest PE dispersion, and from Fig 3.34 that the Geminids show by far the largest range in dynamic pressure. I think this issue of material properties should be discussed in more detail. If the degree of variability in PE and dynamic pressure for the Geminids is common knowledge, and has already been associated with alteration of the parent comet or fragments, then discuss that and reference the relevant literature. If variability in PE and dynamic pressure has not been linked to alteration then there is clearly a very nice story here, and the basis for an important paper.

4) P.38 (and also P.44). Also, the density estimates for Geminids, which appear to cluster around 3-4g/cm^3. Its not that I doubt those literature numbers, but in reviewing them here it would be good to consider the context. They are incredibly high, especially given that the bulk density of a large Geminid meteoroid is likely to be lower than the density of a smaller Geminid meteorite – a fragment of that larger body – if we had one in our hands. With that in mind, it's worth noting that there are very few carbonaceous chondrite meteorites with bulk densities in this range. The best fit would be a low porosity H or L ordinary chondrite - but they contain significant metal. Assuming that we have altered a primitive IDP-type composition – first melting ice, doing some aqueous alteration, and then possibly dehydrating those minerals and doing low-level metamorphism – I would expect a high porosity, oxidised, sintered aggregate. Low metal, porous, and lots of silicates and oxides. Bottom line – it is difficult to see how we could get such high bulk densities. It would be nice to have some discussion of this.
5) P.40. This may well be a silly question, but in the light of subsequent discussion (P.93 etc), given that to get a finite terminal mass we need relatively low initial velocities, is there any possibility in future encounters with the Geminid stream that we would see velocities significantly lower than ~35km/s? Has anyone modelled that?
6) P. 73. Radiants and orbits for Leonids, LEO25 not taken into account. OK, but it would be good to have some discussion about LEO25. Is there any reason why it is such an obvious (and lonely) outlier? On P.67 the candidate mentions that the LEO25 terminal flare corresponded to the highest observed dynamic pressure – so could composition and strength have anything to do with it? Again, a little more discussion would be useful.
7) P.90-96. I like this discussion, and I think that it is a very significant result. This analysis shows that it is quite possible to get Geminid meteorites on the ground. But I do think there might be things that could be done to develop / strengthen the argument. For instance, developing that point from earlier on: is the velocity-frequency distribution for future Geminid encounters likely to be the same? If not, how might that affect meteorite survival? In addition, it would be useful to see the size-frequency distribution (based on initial photometric mass) for the Geminids (combining this data with any other literature data). It would actually be interesting to see this for different streams as well (e.g. do Geminids have a different SFD than Leonids? Given their different strengths, and likely different compositions, I would expect them to), but for now lets focus on the Geminids. I would also consider modelling separate fragments (e.g. something along the lines of Natasha Artemieva's work). This would all go towards answering the larger question, which is: what proportion of Geminid meteoroids in a given encounter should be capable of reaching the ground (based on the velocity-frequency distribution, factoring in the size-frequency distribution (since larger objects will survive even if velocities are higher), and taking into account strength, fragmentation, and ablation of fragments etc). This would obviously be a significant extension of what is presented here, and I'm certainly not suggesting that it should be done for a final version of the thesis. But it might be worth thinking about for a paper on this topic – and there really should be a paper on this, because it's a fascinating result! Apart from anything else, we could use it to calculate how many Geminid meteorites might be present in our existing meteorite collections (given that

there are >30,000 recovered from Antarctica, and many thousands from the Sahara, it might not be that unlikely), as well as the likelihood that a given fireball network configuration might observe a Geminid meteorite fall.

In summary, as outlined above, a few areas of discussion could be developed further, but the work presented here is of a high standard and certainly justifies awarding a PhD.

Yours faithfully,

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