

Reply to Referee #1 on the manuscript "Thermospheric shock waves and lensing of light in the Barium Release, Optical and Radio rocket experiment", by Leyser et al.

We thank the referee for the constructive comments on the manuscript. We have discovered an error in the data analysis concerning the lensing effect so that we are not convinced of its presence any longer. All text and one figure concerning the lensing has therefore been removed. Also, the reference to lensing in the title has been removed. However, this does not affect the main theme of the manuscript, namely the results on the shock waves themselves. Below is our response to the comments in the review report.

1. A brief review of the scientific purpose of the BROR experiment has been added in the Introduction. However, a more detailed overview of previous experiments than that already given, and also to add both Zhu et al. (2020) and Fletcher et al. (2023) which are on plasma effects from barium release experiments, is beyond the scope of the present work. As described in the Introduction, the present manuscript is on effects in the neutral thermosphere, not on plasma (or ionospheric) effects. Although the main goal for the BROR experiment was the ionospheric and electrodynamic effects, it would side track too much to review these in addition to neutral gas effects that are the subject of the present manuscript. The reference to Taki et al. was included already in the original manuscript for the main goal of the BROR experiment.
2. Figure 1 has been added to show the geometry of the experiment as relevant to the present study. Additional information on the BROR experiment and conditions has been added in the text, mainly in the Introduction and the first paragraphs in Observations. However, as mentioned above the focus of the present manuscript is on local effects in the neutral thermosphere immediately following a barium release, it is therefore not relevant to give an overview of the global characteristics of the BROR experiment. This is the topic of the paper by Taki & al. which is on ionosphere-magnetosphere coupling and which is referred to, and possibly other papers to come. However, all data has been given that is needed for the purpose and level of accuracy in the present treatment.
3. The section Discussion was accidentally numbered as a subsection to section 2, although it should be a separate section 3. This has been corrected so that the derivation of the speed of the shock waves is in section 2 (Observations) and the interpretation in terms of the radius of the copper droplets is in section 3 (Discussion). Examples of all cases are shown in figures 2-5 (Observations). In this way results obtained directly from the observations, such as the shock speeds, are kept separate (in Observations) from the interpretation of these results in terms of copper droplets, which belongs to the Discussion. We use this structure in the manuscript for scientific clarity, to keep observations separate from the interpretation of the observations.
4. The observations are already presented individually in separate figures and in separate descriptions of the observations, although not in separate subsections. For clarity, we present examples of series of images from all cases discussed. This is then followed by presenting, again in separate figures, the speeds obtained from the series of images. We judge that to repeat the presentations in three separate subsections, one for each release, would introduce repetitions that would make the text less fluent. Also, as noted from the outset in the Introduction, previous measurements of shock waves were done only through their ionospheric effects, not directly in the neutral gas of the thermosphere as in the present study. And, as already mentioned in the Introduction, the previous observations of shock waves through their ionospheric

effects were from much larger and more powerful rockets than the BROR rocket. Taken together, a further comparison with previous measurements is not possible.

5. We do not understand this comment. The observations are repeated in this section and interpreted in terms of shock waves due to sprays of copper droplets in the neutral thermosphere (so no electrodynamics is involved for our interpretation).
6. We do not understand this comment. The observations and our interpretation are summarized. We have changed the section heading from Conclusions to Summary, to be more consistent with the content of the section.
7. We do not understand this comment. Links to the video data that was used were given. In the revised manuscript the link to the video from the Vittangi camera on the lensing effect has been removed, as mentioned above, and only that for the Sodankylä video remains.