MODELLING THE PARTICLE AND PHYSICAL MAKEUP OF METEOROIDS.

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Introduction: Every night, the Cameras for All-sky Meteor Surveillance (CAMS) project detects hundreds of meteors and calculates their trajectory and orbit to map our meteor showers. Each meteors' light curves is recorded along with other parameters such as height, velocity, and deceleration. That data is saved into the CAMS database.

In this SETI Institute Research Experience for Undergraduates program study, we worked to implement into the CAMS data processing pipeline a numerical meteoroid model that fits the meteor lightcurves as a function of height and that outputs relevant parameters on particle size distribution and thermal and physical properties of the meteoroids.

Methodology: In order to create this model, three objectives needed to be considered: Firstly, the model should be able to simulate a lightcurve and velocity profile closely matching the observations in a reasonable amount of time. Secondly, the model should extract meaningful physically parameters. Thirdly, the model's output should be written to an output text file that integrates to the CAMS data processing pipeline.

Our starting point was an existing MATLab code that had implemented the meteoroid ablation model of Campbell-Brown et al. [1]. The model assumes that a meteoroid will start breaking up once the melting temperature of the "glue" of the meteoroid is reached. Once this glue temperature is reached, the glue melts and solid grains of the meteoroid are released. Those solid grains then ablate according to classical meteor ablation theory.

This code was translated into Python. The code was further improved by implementing the grain erosion model by Borovička, Spurný, and Koten [2]. It assumes a more continuous fragmentation of the meteoroid, resulting in smoother light curves.

Further improvements were made. For the atmospheric density and temperature in the upper atmosphere, for example, we fitted 7th and 9th degree polynomials to the respective logarithmized outputs of the MSISE-90 atmospheric model. The logarithmized temperature versus height was specifically fit with two 9th degree polynomials since the MSISE-90 model outputted a sharp rise in temperature starting at 100 km in altitude.

Results: An example of the height versus magnitude output of the model with manually inputted free parameters is shown in Fig. 1. An improved fit could perhaps be obtained when exploring the parameter space, but that required a long run time.

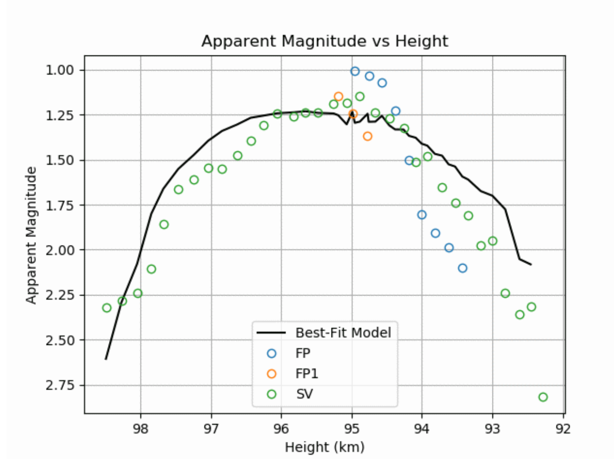

Figure 1. The output of the model with manually inputted parameters versus the detected magnitudes of a meteor. The meteor was detected on December 14th, 2015.

Discussion: One way to solve the long run-time problem is to limit the parameter space. For example, the lightcurve's f-parameter, the measure of how lopsided the light curve is, could estimate the size distribution index. Another method in optimizing the run time is to utilize one of the many available mathematical optimization algorithms available.

Overall, the new software tool is a good starting point towards implementing a pipeline tool to extract the various physical parameters of detected meteors.

Conclusion: In order to obtain the physical parameters of detected meteoroids, a model was created in order to produce a best-fitting light curve for each meteoroid. This model was then implemented into the pipeline of the SETI CAMS project. While the model has a qualitatively good fit for sample meteor, more work needs to be done in order to for it to run through the many detected meteors efficiently.

References: [1] M. D. Campbell-Brown et al. "Model of the ablation of faint meteors". In: *Proceedings of the International Meteor Conference, 22nd IMC, Bollmannsruh, Germany, 2003*. Ed. by M. Triglav-Čekada and C. Trayner. Jan. 2004, pp. 13–22. [2] J. Borovička, P. Spurný, and P. Koten. "Atmospheric deceleration and light curves of Draconid meteors and implications for the structure of cometary dust". In: 473.2 (Oct. 2007), pp. 661–672. DOI: 10 . 1051 / 0004 - 6361 : 20078131.