Planetary Group, UCL Mullard Space Science Laboratory

# Investigating Fine Scale Structures in Comet Dust Tails

Overlaying a Finson-Probstein diagram onto Comet Dust Tail images to enable convenient and direct comparison and analysis of the tail's fine-scale structure

Qasim Afghan

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MSSL PhD Student

Supervisor: Prof. Geraint Jones

# Introduction and Context

The sublimation of ices on comets cause dust grains to be blown off its surface. Radiation pressure from the Sun causes the dust grains to depart from the comet's orbital trajectory and produce a dust tail as seen in Figure 1.

Fine scale structures in the dust tail are of particular interest in this project. These include striae, which are narrow, linear bands of dust in the dust tail (seen in Figure 1). The properties and time evolution of these structures are not yet completely understood [1].

Modelling comet dust tails are a powerful analysis tool to study their structure, but the current public resources available don't provide a convenient and direct way to compare the modelled and real dust tail. This project aims to address this issue, and show examples of how beneficial this new analytical tool can be.

*Figure 1: Comet McNaught (2007)*
*Credit:* S. Deiries/ESO [2]

# Method

The Finson-Probstein model [3] is used to simulate the trajectory of dust particles. This simulation spans from the time that the image was taken to up to approximately a month before (this varies for each image).

The location of the image in the night sky (in a Right Ascension and Declination coordinate system) is ascertained using an online astrometry algorithm that recognizes star patterns in the image to determine its location [4].

These dust particle positions are projected onto the image. The modelled dust positions can then be directly compared with the real dust tail in the image. For clarity in the plot, two sets of lines are plotted on the dust tail: lines that join simulated dust particles that have the same value of dust beta ("syndynes"), and lines that join simulated dust particles that were ejected from the comet's nucleus at the same time.

These line plots, or Finson-Probstein diagram, are then compared to structures in the dust tail.

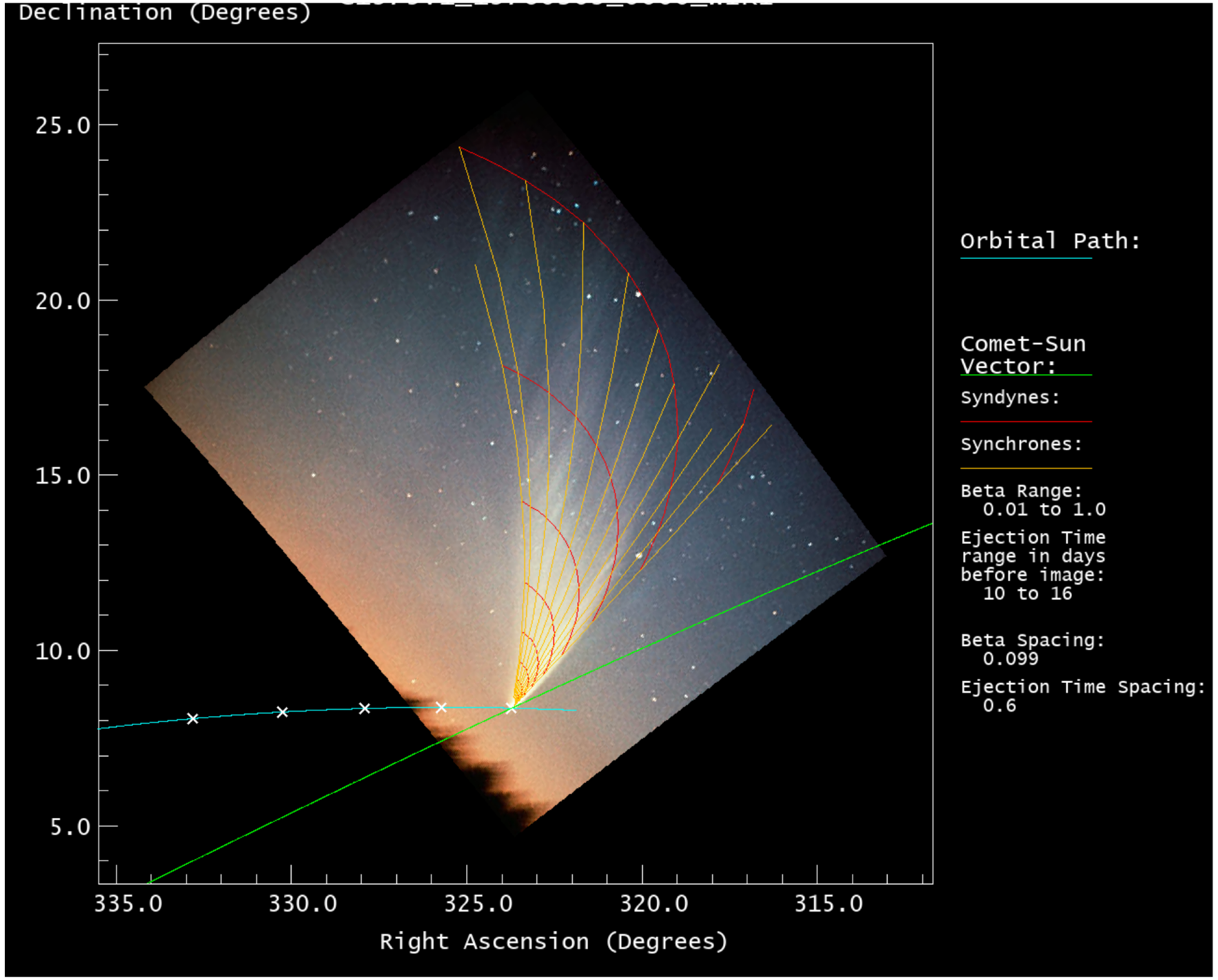


*Figure 2: Finson-Probstein overlay plot on an (unprocessed) image of Comet West (1976) [2]. Striae are partially visible in the image. Details of the plotted lines are shown on the right of the plot.*

# Results and Discussion

This work is a continuation of similar analysis carried out on Comet McNaught, for which the initial model was created[5]. This was used as a basis to build a more generalized model to analyse any (viable) comet image input.

This generalized model has been successful in producing analysis plots for several comet images, and further analysis of these images is now made much more convenient. Ongoing work with the current sets of results involve comparing the lines of constant dust ejection time ("synchrones") to the striae alignment. A generalized image processing pipeline has been created to accentuate the fine-structure details in the images.

Notable results from the previous McNaught study [5] included striae crossing each other, which is likely due to a crossing of the heliospheric current sheet, and dark 'bands' observed to be moving across the dust tail. With this new generalized analysis tool, many more comets are being analysed to spot these same features and understand them.

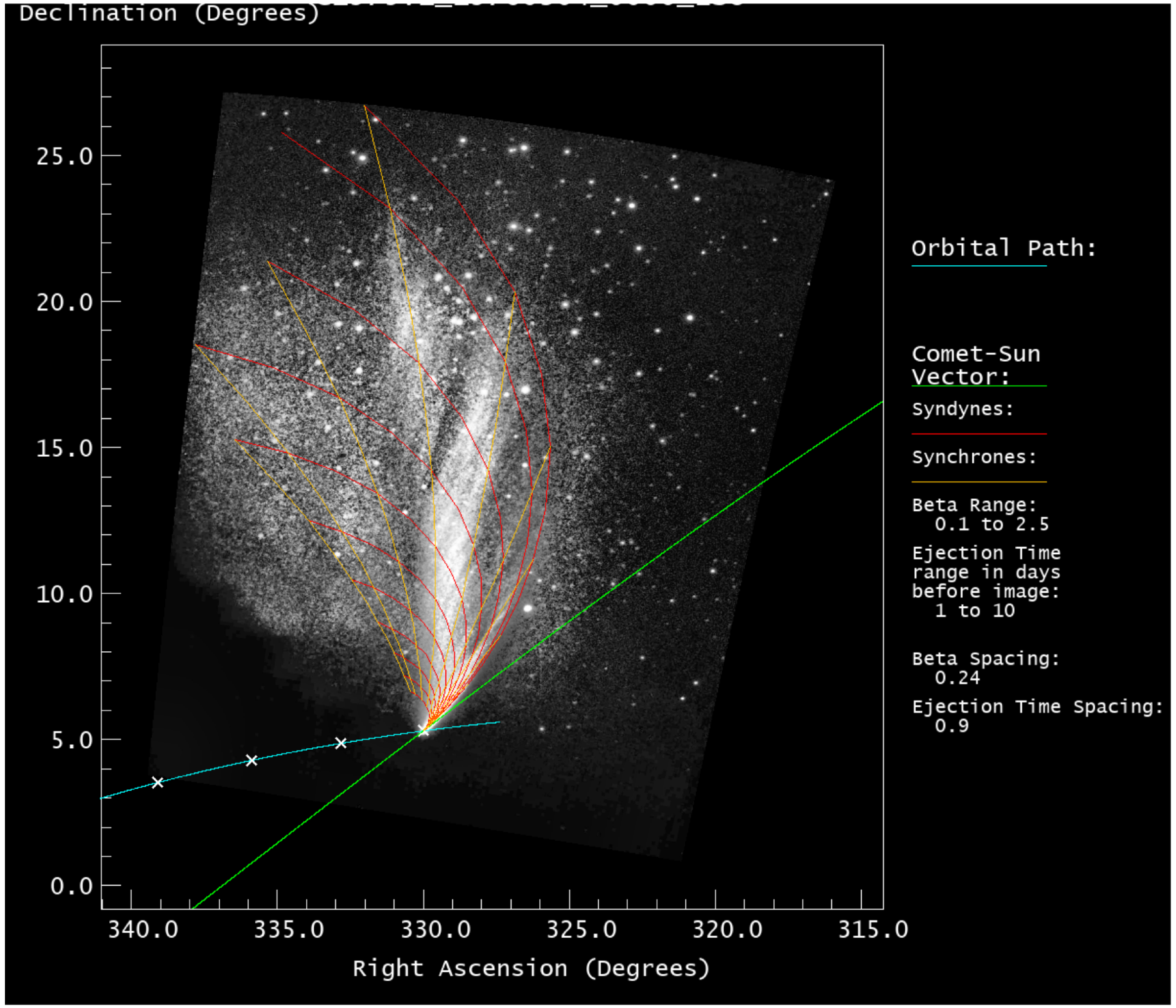


*Figure 3: Finson-Probstein overlay plot on another (processed) image of Comet West (1976) [2][6]. The modelled synchrones (yellow) trace out bright arced bands in the image, which are know as 'synchronic bands', and give us values for the dust beta values of these bands. Striae can also be seen in the image.*

# Conclusion and Future Work

The analysis script has been successful with overlaying Finson-Probstein diagrams onto a variety of comet images. The plots produced so far are currently being analysed further.

Investigating how these structures evolve over time is the main focus of future work. Comet PanSTARRS L4 2011 (Figure 4) is an example of an ideal candidate for this, as the images captured by NASA's STEREO spacecraft show the striae of the dust tail very clearly, and show how these features evolve over time.

This work is part of a larger project to produce an automated comet tail analysis pipeline. The ultimate aim is to produce software that automatically analyses comet dust tails and features from an image. The abundance of professional and amateur images of comets poses a daunting task for detailed analysis. An automated pipeline such as this endeavours to improve the accessibility of comet dust tail analysis for researchers. Furthermore, the robustness of the software allows us to access the extensive database of amateur astronomer comet observations and images, and hopefully further promote collaboration with the amateur astronomer community.

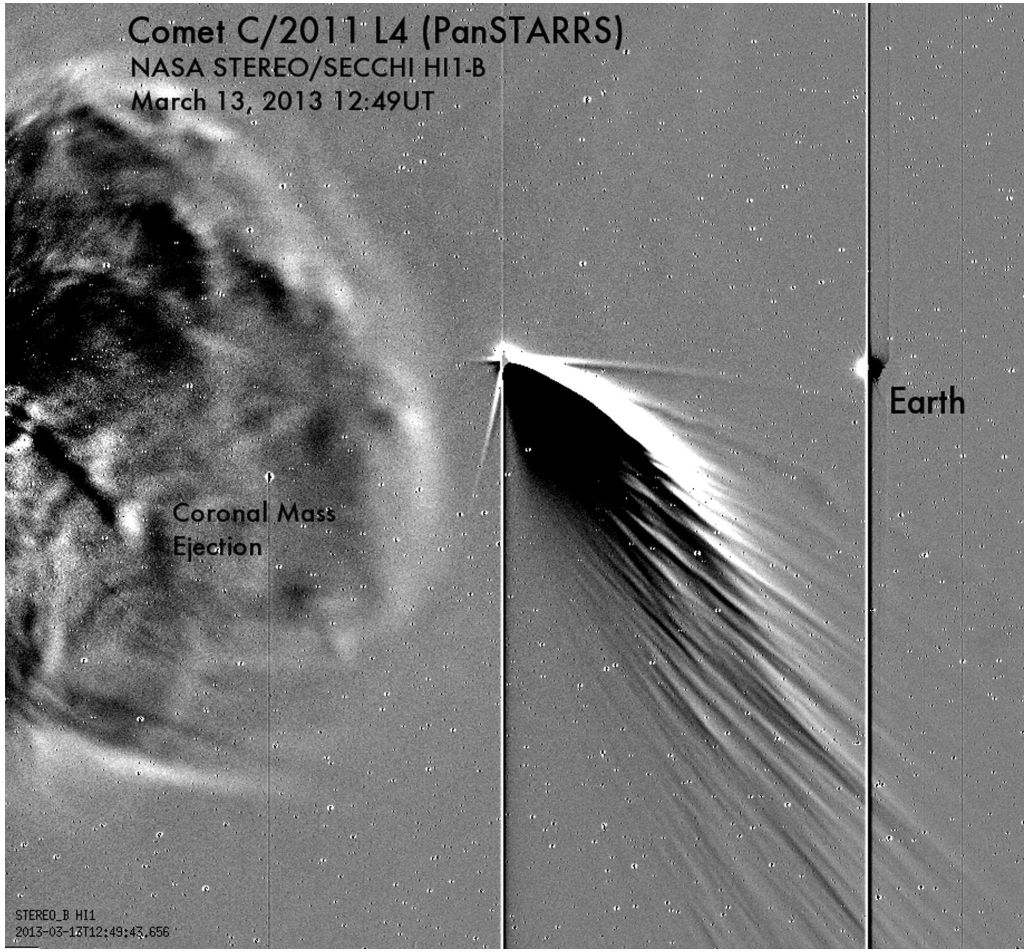


*Figure 4: Comet PanSTARRS (2011)*
*Image from NASA STEREO Science Centre Image Database [7]*

# References

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*Figure 5: Comet Lovejoy (2011)*
*Photograph by Alex Cherney, TWAN [8]*