Comet-toolbox: numerical simulations of cometary dust tails in your browser

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The last few years have seen a rise in the popularity of comets, on both professional and amateur levels. Many cometary events, sometimes visible without a telescope, have triggered worldwide campaigns of ground and space based observations. For instance: the explosion of comet 17P/Holmes, the sungrazers C/2006 P1 (McNaught) and C/2012 S1 (ISON), or the forthcoming close encounter of C/2013 A1 (Siding Springs) and Mars. With the overwhelming amount of data available, it becomes more and more important to release the models we use to analyze these events. This ensures not only that more people get the opportunity to investigate the data, but is also beneficial for the science itself as everybody is able to see, use, and improve the models.

As a professional planetary scientist, I have written many tools to process the data I use, especially in the field of cometary and asteroid science [1, 2, 3, 4, 5, 6]. With the progress of modern computers, it is now possible to translate this tools to simple HTML/Javascript interfaces and run the models in an Internet browser. I have decided to make my tools available in this way, to be used by anybody interested in modeling cometary processes. The first tool being released at ACM 2014 is the Finson-Probstein diagram.

The motion of dust particles in a cometary environment is a complex process. A precise description of the grains trajectories requires advanced hydrodynamic models. In the tail, dust and gas are decoupled and the only significant forces affecting the grain trajectories are the solar gravity and radiation pressure. Both forces depend on the square of the heliocentric distance but work in opposite directions. Their sum can be seen as a reduced solar gravity, and the equation of motion is simply $m \times a = (1 - \beta) \times \mathrm{Sun}_{gravity}$, where β is the ratio $P_{radiation}/\mathrm{Sun}_{gravity}$, and is inversely proportional to the size of the grains for particles larger than 1 micron.

From this relation, Finson & Probstein (1968, [7]) proposed a model which describes the full tail geometry with a grid of synchrones and syndynes; lines representing respectively the locations of particles released at a same time, or with the same β. This model is simple because it considers only particles released in the orbital plane of the comet, and with zero initial velocity, but it provides a very good approximation of the shape of the tail, and has been used successfully to study many comets. One of the many strengths of this approach is the possibility to date events in the tail. For instance, one can understand if regions of higher density are related to outbursts of the nucleus, or are a result of fragmentation of large chunks of material within the trail. It can also be used to disentangle between continuous activity, short outbursts, or impacts, when all these events produce a feature which at first look like a normal cometary tail.

The model can be found at http://www.comet-toolbox.com

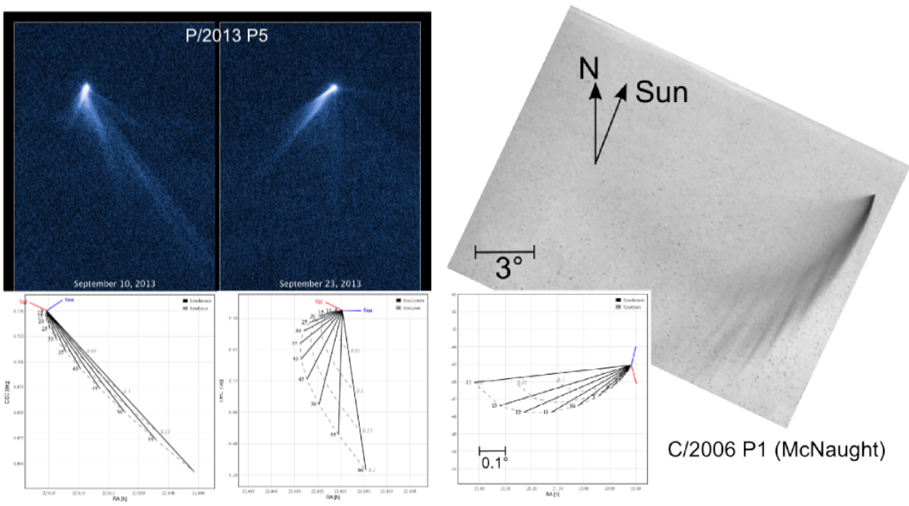

Figure: Example of FP diagrams for the active asteroid P/2013 P5 and the comet C/2006 P1 (McNaught)

References: [1] Vincent et al, Earth, Moon & Planets, 2010 [2] Vincent et al, Astronomy & Astrophysics, 2010 [3] Snodgrass et al, Nature, 2010 [4] Lin et al, Astronomy & Astrophysics, 2012 [5] Vincent et al, Astronomy & Astrophysics, 2013 [6] Hainault et al, Astronomy & Astrophysics, 2014 [7] Finson & Probstein, The Astrophysical Journal, 1968