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Constraining activity models of comet 67P/Churyumov-Gerasimenko with Rosetta data

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1. Introduction

Comet outgassing produces a reaction force on the nucleus which changes its rotation and trajectory. Using measurements made by the Rosetta spacecraft, we can constrain outgassing models to better understand this activity.

Here, we use the measured total water production rate [1], as well as nucleus torque and ranging curves, derived from optical and radio navigation, to constrain a thermal outgassing/non-gravitational force model of 67P/Churyumov-Gerasimenko.

2. Modelling

We use a comet thermal model [2] including: varying solar insolation, water sublimation, self-shadowing and heating, but zero thermal inertia, in order to calculate the surface temperature and water sublimation rate of each facet of a shape model with time. The reaction force per facet can then be calculated, assuming a momentum coupling factor, η, and an effective active fraction (relative to a pure water ice surface). The thermal model is run at a number of points over a comet rotation and the relevant quantities averaged over the day. This is then repeated over the comet's orbit to produce time varying curves for comparison with the measured water production and torque. For the trajectory, a full N-body integration must be performed and the resulting comet position compared at each time. We use the open-source $REBOUND$ code, complete with full general relativistic corrections and gravity of all major solar system objects. 67P is initialised with its position given by the SPICE kernels and the system is then integrated forward in time, using the IAS15 integrator, with the addition of an extra acceleration term provided by our model. We then directly compare the

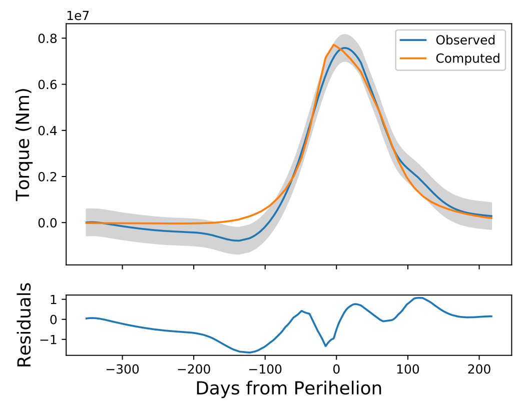

Figure 1: Observed and computed torques and residuals for our best-fit solution.

modelled and observed magnitudes of the comet-to-Earth range (the most accurate part of the trajectory).

We perform a bounded least-squares fit to the residuals (linearly scaling the three datasets to roughly the same magnitude), optimising for the effective active fraction of a number of regions across the comet's surface.

3. Results

Optimisations with 5 regions, as used by [3], or the full 26 regions defined by [4] fail to adequately reproduce the data. In order to fit the positive torque peak at perihelion (Fig. 1) we had to split the southern hemisphere region of [3] by torque efficiency (a geometric factor; see Fig. 2), while to fit the production rate and trajectory curves (Figs. 3, 4) a time-varying active fraction was needed (see Fig. 5).

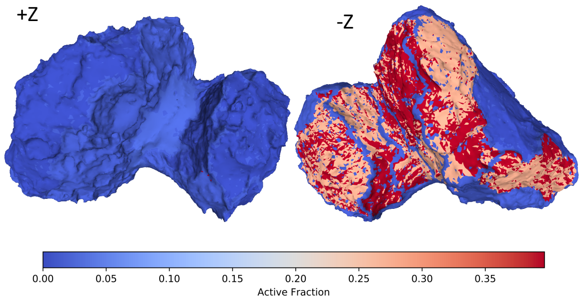

Figure 2: Mapped peak active fraction for our best-fit solution.

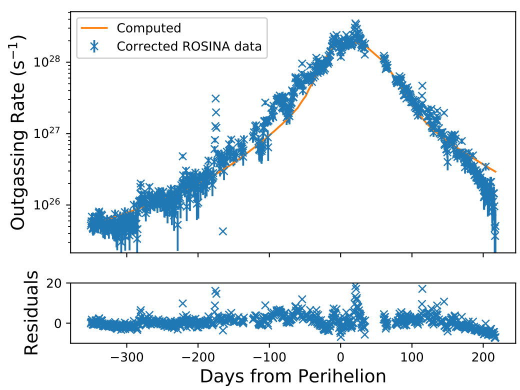

Figure 3: Observed and computed water production rates and residuals for our best-fit solution.

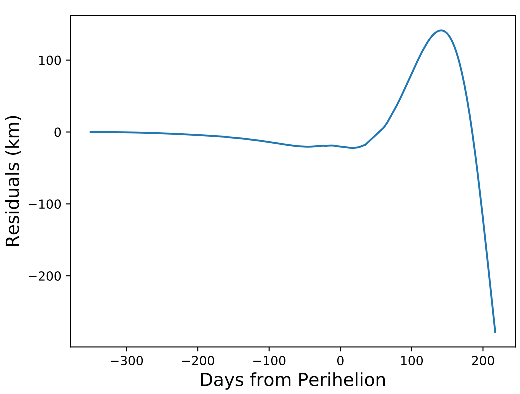

Figure 4: Observed minus computed range for our best-fit solution.

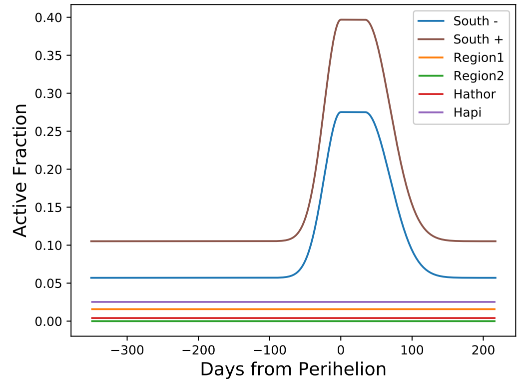

Figure 5: Active fraction with time for our best-fit solution.

4. Summary and Conclusions

Our best-fit solution suggests that: the southern hemisphere has a high active fraction compared to the north; active fraction varies significantly, both spatially and temporally; the data cannot be explained by purely seasonal solar variations and active fractions must increase near perihelion.

A time-varying active fraction could be explained by changing dust cover, which would generally stifle activity, except where it is lifted by intense perihelion outgassing, exposing more of the surface. Additonal work will be done to constrain η.

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References

[1] Hansen, Altwegg, Berthelier, et al., MNRAS, 462, S491, 2016.

[2] Groussin, Jorda, Auger, et. al., Astronomy & Astrophysics, 583, A32, 2015.

[3] Marschall, Su, Liao, et. al., & Vincent, Astronomy & Astrophysics, 589, A90, 2016.

[4] Thomas, Sierks, Barbieri, et al., Science, 347, 2015.