# Comet Siding Spring (C/2013 A1) and its close approach to Mars

T. Farnham[1], M. Kelley[1], D. Bodewits[1], J. Kleyna[2], J.-Y. Li[3], R. Stevenson[4], and J. Bauer[4]

[1]University of Maryland, College Park, MD 20742, USA
[2]Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[3]Planetary Science Institute, Tucson, AZ 85719, USA
[4]Jet Propulsion Laboratory, 4800 Oak Grove Dr, Pasadena, CA 91109, USA

Comet Siding Spring (C/2013 A1) is a dynamically new comet that was discovered in January 2013. On 19 October 2014, it will pass within 135,000 km of Mars, a distance less than 1/16th that of the closest known approach of a comet to the Earth. This event is essentially a natural flyby, where spacecraft orbiting Mars have the opportunity to obtain the first ever high-resolution observations of a dynamically new comet. In anticipation of this event, we undertook a study to characterize the comet's behavior, and to use that information to predict what the dust environment will be like at the time of the close approach. This information was used by the orbiter teams to evaluate the potential hazards to their spacecraft and develop mitigation strategies that might be needed, as well as allowing for detailed planning of any comet observations.

We incorporated observations from PanSTARRS, HST, Swift, NEOWISE and ground-based observatories to characterize the comet's properties. Results from the analyses of these data indicate that Siding Spring was behaving much like comet ISON (C/2012 S1) at similar distances. It first became active between 10 and 8.0 au, and brightened through ∼6 au. From 6 to ∼3 au, its brightness remained nearly constant, following the typical behavior of dynamically new comets. The activity through early 2014 was likely driven by $CO_2$ emission, which was found to be $1.4 \times 10^{26}$ mol/sec from the 4.6 µm excess in NEOWISE observations. (We assume the excess is due to $CO_2$ because the activity was low until around 10 au). As of March 2013, there were no detections of water or OH production, though Swift measurements produced an upper limit of $Q(H_2O) < 3 \times 10^{27}$ mol/sec at 3.2 au. Dust properties were derived using $Af\rho$ measurements, as well as analyses of the dust coma and tail morphology in the HST and ground-based images (using the sunward standoff distance, Finson-Probstein modeling, etc.). From this work, we found a particle size distribution $f(a) \sim a^{-4.0}$ and dust velocities $v \sim 400\, a^{-0.6}\, r_h^{-1.5}$ m/s. This dependence indicates that the grains have very low velocities (10 s of m/s for 10–100 µm grains) at 5 au. We use these results to produce a nominal model of the comet's activity as a function of time, as well as a more extreme-case model that allowed worst-case conditions to be explored.

With our models of the comet's activity, we performed a series of Monte-Carlo simulations to explore the dust environment and the conditions that would be present around Mars during the close approach. These simulations followed $10^7$ particles, emitted isotropically, from 13 to 1.4 au. The coma was modeled by tracking the grains' motions under the influence of their initial emission velocity, solar gravity and radiation pressure, and computing their positions at the time of close approach. Results from these simulations reveal that the comet will make only a 'glancing blow' on Mars, with relatively few impacts, due to radiation pressure rapidly accelerating the smaller grains so they tend to miss the planet. The impact potential of the larger grains (100 µm- to cm-sized) is strongly dependent on their velocity, but based on the results derived from the observational data, the number of impacts will still be small. In the nominal case, no impacts are expected at Mars, but variations in our assumptions raise the average fluences to no more than a few$\times 10^{-7}$ particles/$m^2$. In these scenarios where impacts occur, the peak is encountered 90–100 minutes after close approach, when Mars comes closest to the comet's orbital path (i.e., the dust trail), with a duration of ∼0.5 hour. The grains that do impact Mars were ejected from the nucleus when it was more than 5 au from the Sun, so the comet's activity levels interior to that distance have little impact on the analysis.

**Acknowledgements:** This research was performed under funding from the Mars Program Office, Critical Data Products Program.