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Comets and Carbon Dioxide

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Abstract

We present a 25-year database of comet photometry and discuss how this can be combined with the *Spitzer* large comet survey and the *WISE* Survey data to investigate the role of carbon dioxide activity in comets and the relation to proto-planetary disk chemistry. The Earth's atmosphere is opaque at the wavelengths at which CO_2can be observed, and this will give us a new means of exploring the distribution of CO_2in the solar system.

1. Introduction

With stunning images of CO_2–controlled jets at perihelion, the*EPOXI* encounter [1]with comet 103P/Hartley 2, has changed our paradigm of cometary volatile composition and activity mechanisms with respect to CO_2, providing new constraints for proto-planetary chemical disk modelsand volatile distribution. Protoplanetary disk observations show that the planet-forming zone's chemical environment is extremely rich, with water and carbon dioxide as likely tracers of planet formation [2].

1.1Data Sets

We are part of the *SEPPCoN* large *Spitzer* program that has determined radii for ~88comets and the *WISE/NEOWISE* IR-sky survey mission that will result in radii and CO_2 production estimates for >100 comets (combined with the 18 *Akari* CO_2 measurements). Our 25-year database of optical comet observations has heliocentric lightcurves of the scattered light from the dust for 25% of these comets over several apparitions, and there are published spectra giving water production rates for 25% of the set. We are undertaking an observing program to enable us to combine all the data sets to map out and model the distribution of CO_2driven-activity in comets.

As was seen from *EPOXI*, the outgassing jets on comet 103P/Hartley 2 lifted large chunks of icy material from the nucleus, and it was sublimation from this increased surface area that gave the mission target such a large apparent fractional active area. We have used our *Spitzer* nucleus size data to infer active areas from comets with published water production rates [3], to identify other potentially CO_2-rich comets (see Fig. 1).

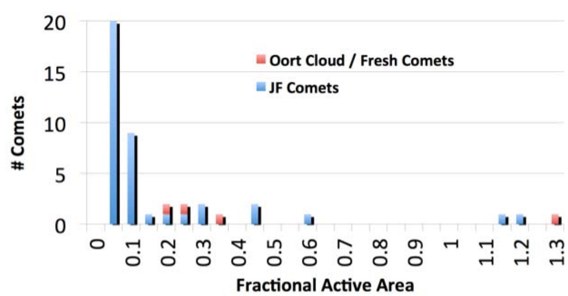

Figure 1: Distribution of fractional active areas from *Spitzer* and*WISE* nucleus sizes combined with H_2O production rates [3]. Comet 103P/Hartley 2 is the point near fractional active area = 1.1.

2. Models

We have used simple surface sublimation code to model the heliocentric light curves for 2 comets with large fractionally active surface areas, 65P/Gunn and 74P/SmirnovaChernykh. Both comets have orbits that lie almost entirely within the asteroid belt and both comets are always active. 65P/Gunn has a large dust trail.As shown in Fig. 2, which presents light curves for scattered light from dust driven from the surface from CO_2 and H_2O–ice sublimation, the models are consistent with CO_2-controlled activity near aphelion, and as the comets approach perihelion, outgassing from water-ice also plays a role.

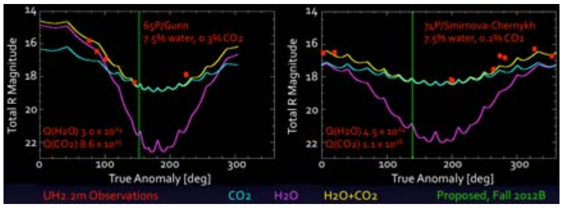

Figure 2: Ice sublimation models for 65P/Gunn and 74P/Smirnova-Chernykh showing that the heliocentric light curve is consistent with CO_2-driven activity.

These comets have been observed with the *WISE* spacecraft, and using the technique described in [4] to estimate the CO_2 flux, we find that both comets are enriched in this volatile. An example, for comet 65P/Gunn, is shown in Fig. 3. The production rate observed from *WISE* is in agreement with the preductions from the thermal models.

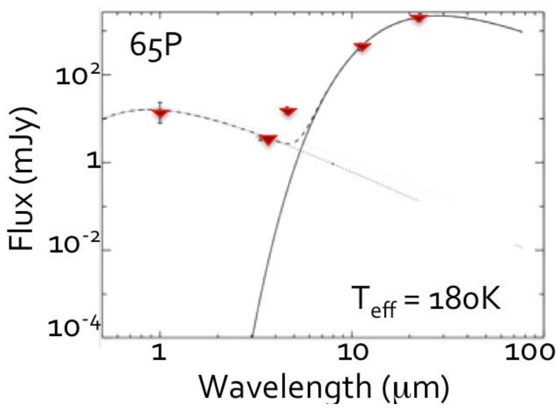

Figure 3: Thermal and reflected spectral fitsto comet 65P/Gunn *WISE* and ground-based photometry showing the enhanced flux at 4.26 μm which is attributed to emission from CO_2.

3. Summary and Conclusions

We will present *WISE* observations, sublimation-models of comets 65P/Gunn, 74P/Smirnova-Chernykh, and of comet 22P/Kopff and discuss the implications of CO_2-driven activity. We are at the point of being able to merge studies of solar system chemistry as seen from these primordial leftovers of the planet building process with chemical models of protoplanetary disks, with a new ability to make resolved disk chemistry observations with ALMA. A large data set with radii, albedos, water and CO_2 production rates will allow us to look for correlations between chemistry in comets, mechanisms of activity and formation location and dynamics.

Acknowledgements

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References

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