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ICARUS
Icarus 195 (2008) 938–940
www.elsevier.com/locate/icarus

Comment

Comment on "Comparison of the composition of the Tempel 1 ejecta to the dust in Comet C/Hale–Bopp 1995 O1 and YSO HD 100546" by C.M. Lisse, K.E. Kraemer, J.A. Nuth III, A. Li, D. Joswiak [2007. Icarus 187, 69–86]

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Received 10 May 2007; revised 13 August 2007

Available online 7 February 2008

Abstract

Lisse et al. [Lisse, C.M., Kraemer, K.E., Nuth III, J.A., Li, A., Joswiak, D., 2007. Icarus 187, 69–86] recently presented a new analysis of an ISO spectrum of Comet C/1995 O1 (Hale–Bopp), from which they claimed the identification of many new dust species. Among them are PAHs, which were not found in our first analysis of the ISO spectra. We present here a re-examination of the ISO observations of Comet Hale–Bopp. From the absence of PAHs features in the 5.25–8.5 µm region, we infer that PAHs are at least twice less abundant than derived by Lisse et al. The carbonate feature at 7.00 µm is marginally present, but lower by a factor 2 to 3 than predicted by the model of Lisse et al.

Keywords: Infrared observations; Comets; Comet Hale–Bopp; Comets, composition

Lisse et al. (2007) recently presented a new analysis of the Infrared Space Observatory (ISO) spectrum of Comet C/1995 O1 (Hale–Bopp), in view of a comparison with the observation of the Deep Impact ejecta of Comet 9P/Tempel 1 with the Spitzer Space Telescope (Lisse et al., 2006). They claimed identification of many new dust species. Among them are polycyclic aromatic hydrocarbons (PAHs), which were not found in the first analysis of the ISO spectra (Crovisier et al., 2000), and carbonates. We present here a re-examination of the ISO observations of Comet Hale–Bopp, which does not confirm the detection of PAHs by Lisse et al. A carbonate feature is marginally present at 7.0 µm, with an intensity 2 to 3 times smaller than expected from the model of Lisse et al.

We will concentrate on the 5.25–8.5 µm region, where PAHs have two strong bands at 6.22 and 7.60 µm and carbonates have a strong band at 7.0 µm. Other species (among those considered by Lisse et al.) do not show significant bands in this region.

The ISO data analyzed here consist of two sets of observations performed around 27 September and 7 October 1996, when the comet was at 2.93 and 2.82 AU from the Sun, respectively. For each set, a Short Wavelength Spectrometer (SWS) full spectrum (with spectral resolution degraded to 500 after reduction), and a 5.8–11.6 µm spectrum obtained with the Spectro-Photometer (PHT-S, with spectral resolution ≈90) were obtained. In addition, a deep integration of the 5.8–7.0 µm region was secured on 6 October with high sensitivity, high resolution (≈1200) to study the ν_2 band of water. (Indeed, several rovibrational lines of water were detected; see Crovisier et al., 1997.)

Fig. 1 shows the 5.25–8.5 µm region of these spectra. To account for the different apertures of the instruments (24 × 24 arcsec for PHT, 14 × 20 arcsec for SWS), the PHT spectra were scaled by a factor of 0.70. A model of the PAH spectrum, adapted from Draine and Li (2007), is plotted to show the expected wavelengths and shapes of the PAH bands (ionized $C_{14}H_{10}$ is assumed).

The signal was stronger on 26–27 September than on October 6–7, as can be seen from both SWS and PHT-S spectra. For both dates, the SWS spectra do not closely match the PHT-S spectra, which may be attributed to the difficulty to estimate the zero level of the SWS spectra and the fact that the SWS instrument uses different detectors below and above 7 µm.

The low resolution of the PHT-S spectrometer is still appropriate for the study of the broad features of PAHs and carbonates. The PHT-S spectra are quite smooth and devoid of any feature.

The spectrum analyzed by Lisse et al. was the 7 October SWS spectrum. It does not show any conspicuous feature. However, it presents a negative feature at 7.95 µm, which could alternatively be interpreted as a weak emission at 7.8 µm; this latter does not match the expected PAH emission at 7.6 µm. The 26 September SWS spectrum, which is of better quality, especially above 7 µm, is quite featureless.

For a quantitative evaluation, we have performed a least-square fit of the intensity of the expected features to the observed spectra. To account for the continuum, that we have not attempted to model, we used a polynomial baseline of second degree, restricting the fit to a wavelength region extending between 3 and 4 times the width of the expected feature. The results are reported in Table 1 and shown in Fig. 2. For comparison, we have listed in the same table the

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doi:10.1016/j.icarus.2007.08.045

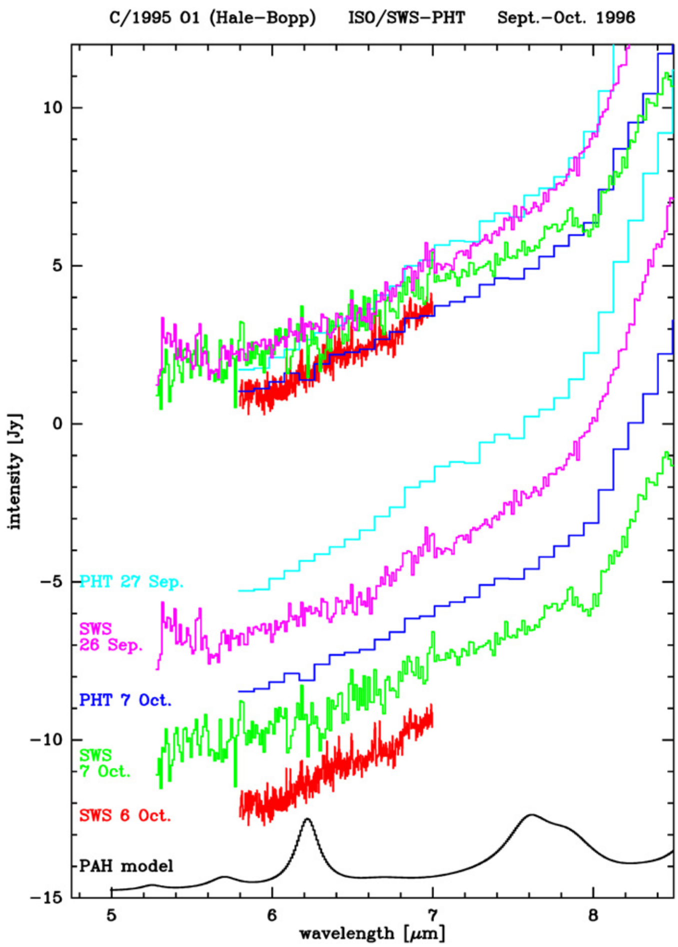

Fig. 1. ISO spectra of Comet Hale–Bopp and PAH model. The five available spectra are plotted with the same scale on the top of the figure, and are repeated, separated by vertical offsets, on the bottom. The PAH model used by Lisse et al. (2007) is plotted at the bottom with an arbitrary intensity.

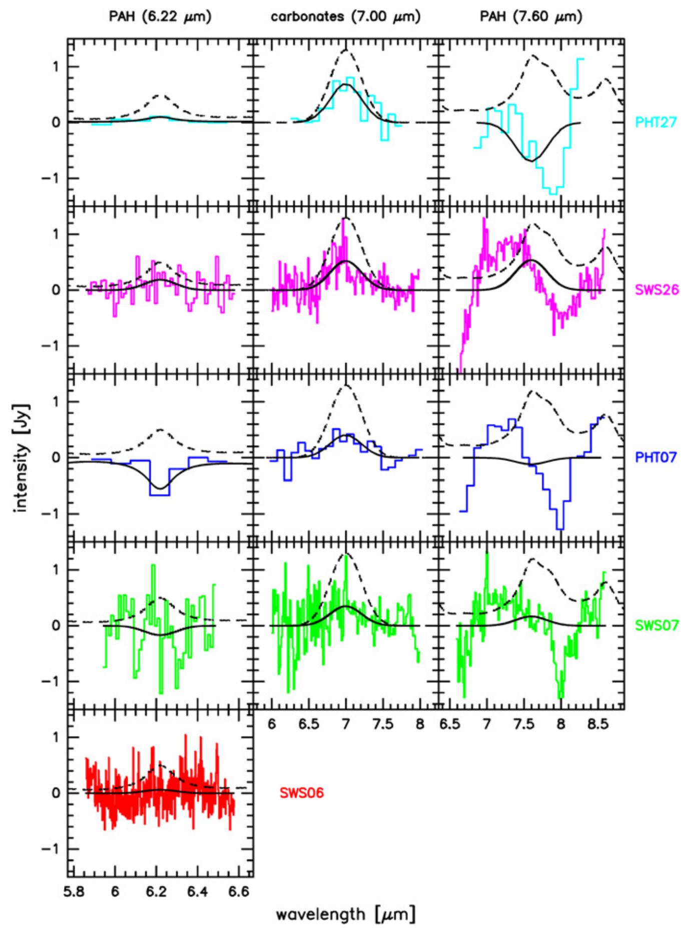

Fig. 2. Fits of PAH and carbonate features to the ISO spectra of Comet Hale–Bopp. The ISO spectra are plotted after the removal of the fitted baselines. The plain black curves are the results of our fits. The dotted black curves correspond to the model of Lisse et al. (2007).

Table 1
Fits of PAH and carbonate features to the ISO spectra

Species	PAH	Carbonates	PAH
λ [μm]	6.22	7.00	7.60
Δλ [μm]	0.18	0.50	0.50
Lisse et al.	0.5	1.3	1.2
PHT 27 Sep.	0.10 ± 0.06	0.70 ± 0.27	-0.70 ± 0.86[a]
SWS 26 Sep.	0.19 ± 0.11	0.52 ± 0.09	0.54 ± 0.25
PHT 7 Oct.	-0.55 ± 0.22	0.41 ± 0.15	-0.12 ± 0.63[a]
SWS 7 Oct.	-0.17 ± 0.26	0.35 ± 0.15	0.17 ± 0.20
SWS 6 Oct.	0.06 ± 0.06	–	–

Notes. The top part of the table lists the features which were fitted, with their central wavelength and their full width at half intensity. The central part lists the intensities from the analysis of Lisse et al. The bottom part lists the results of our fits to the available ISO spectra. All intensities are given in janskys.

[a] Bad fit due to complex baseline.

intensities of the features from the model of Lisse et al., evaluated from Fig. 3a of their paper (it should be noted that in this figure, as was clarified in a personal communication from Dr. Lisse, the carbonates contribution is plotted with a scale factor of 2.0, and the PAH features with a scale factor of 1).

The identifications by Lisse et al. do not rely on a search for individual spectral features, but from the decrease of the residual χ^2 after a fit of the observed spectrum by a modeled spectrum. We think that this methodology may be unreliable when many free parameters are involved. Visual identification and fitting of discrete spectral features are a pertinent approach that may best complement spectral decomposition fitting procedures when assessing weak patterns in low signal-to-noise spectra. The SWS and PHT-S spectra have ill-determined zero levels, so that the measurement of a weak continuum (as is the case here around 5–8 μm) is difficult. Trying to interpret such spectra with a physical modeling of the continuum may then lead to erroneous results, whereas fitting discrete features superimposed over simple, low order polynomial baselines could be justified.

From our analysis of all the ISO spectra of Comet Hale–Bopp, we conclude that there is no hint of PAHs, which questions their detection by Lisse et al. This does not mean that PAHs were absent in this comet, but that their abundance is lower by about a factor of two than the value obtained by Lisse et al.

We cannot exclude the presence of the 7.00 μm carbonate feature in the ISO spectra. Its signal-to-noise ratio, however, is low, and its intensity is lower by a factor 2 to 3 than predicted in the model of Lisse et al.

Acknowledgments

We are grateful to T. Brooke and C. Lisse for fruitful discussions.

References

Crovisier, J., Leech, K., Bockelée-Morvan, D., Brooke, T.Y., Hanner, M.S., Altieri, B., Keller, H.U., Lellouch, E., 1997. The infrared spectrum of Comet Hale–Bopp. In: Heras, A.M., Leech, K., Trams, N.R., Perry, M. (Eds.), The

First ISO Workshop on Analytical Spectroscopy, ESA SP-419. ESA, Dordrecht, pp. 137–140.

Crovisier, J., Brooke, T.Y., Leech, K., Bockelée-Morvan, D., Lellouch, E., Hanner, M.S., Altieri, B., Keller, H.U., Lim, T., Encrenaz, T., Griffin, M., de Graauw, T., van Dishoeck, E., Knacke, R.F., 2000. The thermal infrared spectra of Comets Hale–Bopp and 103P/Hartley 2 observed with the Infrared Space Observatory. In: Thermal Emission Spectroscopy and Analysis of Dust, Disks, and Regoliths. In: ASP Conf. Ser., vol. 196, pp. 109–117.

Draine, B.T., Li, A., 2007. Infrared emission from interstellar dust. IV. The silicate–graphite–PAH model in the post-Spitzer era. Astrophys. J. 657, 810–837.

Lisse, C.M., VanCleve, J., Adams, A.C., A'Hearn, M.F., Fernández, Y.R., Farnham, T.L., Armus, L., Grillmair, C.J., Ingalls, J., Belton, M.J.S., Groussin, O., McFadden, L.A., Meech, K.J., Schultz, P.H., Clark, B.C., Feaga, L.M., Sunshine, J.M., 2006. Spitzer spectral observations of the Deep Impact ejecta. Science 313, 635–640.

Lisse, C.M., Kraemer, K.E., Nuth III, J.A., Li, A., Joswiak, D., 2007. Comparison of the composition of the Tempel 1 ejecta to the dust in Comet C/Hale–Bopp 1995 O1 and YSO HD 100546. Icarus 187, 69–86.