THERMAL MODELING OF COMET KOPFF: IMPLICATIONS FOR THE CRAF MISSION; Paul Weissman and Celia Clause, Earth and Space Sciences Division, Jet Propulsion Laboratory, Pasadena, CA 91109

A thermal model of periodic comet Kopff has been developed to aid in planning for the Comet Rendezvous Asteroid Flyby mission (Neugebauer and Weissman, 1989). The model is based on the comet nucleus model of Weissman and Kieffer (1981, 1983), which estimates the surface temperature distribution and sublimation rates on a rotating icy sphere in heliocentric orbit. Assumed parameters for Comet Kopff are: nucleus radius = 4 km, surface albedo = 0.04, surface density = 0.5 g cm^{-3}, rotation period = 10 hours, and surface thermal inertia = 0.003 cal cm^{-2} $s^{-1/2}$ K^{-1}. The model results are compared with the observed gas production rates from Kopff in 1983. It is found that approximately 15% of the sunlit nucleus surface is active, a relatively high fraction for a typical short-period comet. This suggests that the actual nucleus radius may be larger than the model value. The slope of the observed gas production curve with heliocentric distance is steeper than that predicted by the thermal model. This may indicate the existence of a more complex process than direct sublimation of surface ices, such as gas diffusion through a nonvolatile insulating crust, or may be a result of the orientation of the Kopff rotation axis, which is currently unknown.

If one assumes a nucleus obliquity near zero, then the resulting estimated sublimation rates pre- and post-perihelion are remarkably symmetric, suggesting that any observed asymmetries are the result of the distribution of active areas on the nucleus surface of Comet Kopff. On the other hand, if large obliquities are assumed, then pre- and post-perihelion gas production rates can vary accordingly. However, the greatest variation in gas production rate for high obliquities comes at large heliocentric distances, beyond 2.5 AU. Variations by orders of magnitude are possible. This is because the energy going into sublimation at large distances is comparable to the surface heat flow and radiation terms. Nearer to perihelion virtually all energy goes into sublimation and nucleus orientation becomes a less significant factor.

Estimates of subsurface temperatures on Kopff were of particular interest to the Penetrator experiment which would have delivered an instrumented package to the nucleus surface approximately one year after arrival at the comet, at a heliocentric distance of 4.0 AU (NASA recently de-selected the Penetrator from the CRAF payload). If one assumes a low obliquity for the nucleus, the thermal model results indicate that there will likely be a broad range of 20 to 30° in latitude near the nucleus rotation poles, which meets the Penetrator requirements of temperatures less than 120 K. For higher obliquities the problem becomes more complex, particularly if one must also deliver the Penetrator to a sunlit location. The diurnal thermal wave is not expected to penetrate more than 10 to 30 cm into the surface, assuming the modest thermal inertia used in the model. The estimated gas production rate at 4.0 AU is ~ 10^{24} s^{-1}. These results are relevant to planning for the joint NASA/ESA Rosetta mission which will return a comet nucleus sample to the Earth for detailed analysis.

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References: Neugebauer, M., and Weissman, P. R., EOS **70**, 633, 1989; Weissman, P. R., and Kieffer, H. H., Icarus **47**, 302, 1981; Weissman, P. R., and Kieffer, H. H., JGR **89**, C358-C364, 1984.