Cometary Activity Begins at Kuiper Belt Distances: Evidence from C/2017 K2

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We discuss the development of activity in the extraordinary, distant long-period comet C/2017 K2 over the heliocentric distance range 9 < r_H < 16 AU. C/2017 K2 is an incoming long-period comet with a period so long (~ 3 Myr) that no heat from the previous perihelion can be retained; we can be sure that the observed mass-loss is driven by the current insolation and not by a thermal lag. The comet is characterized by a steady-state coma of sub-millimeter and larger particles ejected at low (4 m/s) velocity, filling a roughly spheroidal coma with a characteristic scale of 80,000 km. In a fixed, co-moving volume around the nucleus we find that the scattering cross-section of the coma, C, is related to the heliocentric distance by a power law, C ~ r_H^{-s}, with heliocentric index s = 1.14+/-0.05. This dependence is significantly weaker than the r_H^{-2}, variation of the insolation as a result of two effects. These are, first, the heliocentric dependence of the dust velocity and, second, a lag effect due to very slow-moving particles ejected long before the observations were taken. A Monte Carlo model of the photometry shows that dust production beginning at r_H ~ 35 AU is needed to match the measured heliocentric index, with only a slight dependence on the particle size distribution. Dust mass loss rates at 10 AU are of order dM/dt ~ 10^3 a_1 kg/s, where 0.1 < a_1 < 1 is the effective particle radius expressed in millimeters.

The expulsion of submillimeter and larger grains, beginning at Kuiper belt distances, is likely the result of the sublimation of near-surface supervolatile ice (probably CO, as suggested by the recent detection of this molecule at 6.7 AU; Yang et al. Ap. J. Letters, in press). Water ice is involatile over the observed distance range and even the energy and gas release triggered by the crystallization of amorphous ice, if present, cannot produce activity at 35 AU. Comet C/2017 K2 will reach perihelion near Mars’ orbit in December 2022.

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