The Rings of ε Eridani

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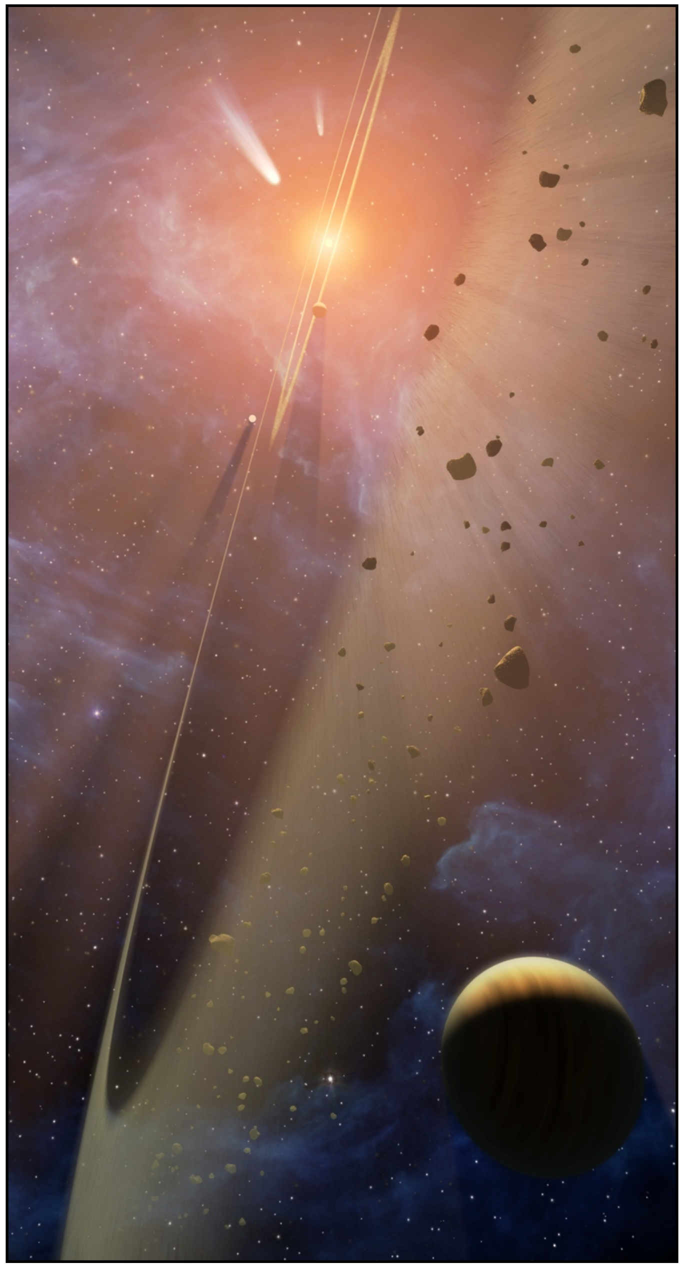
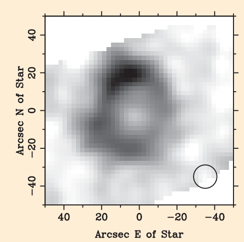


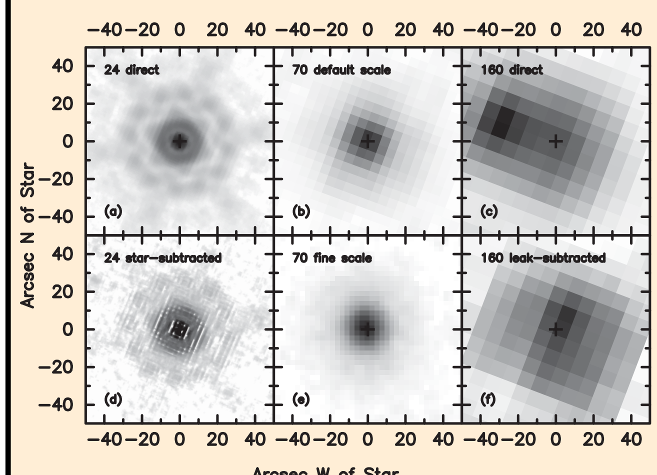
COMPONENTS	r[AU]	$M_T[M_\oplus]$	α	a[μm]	x	L_d/L_*
Inner Warm Belt	3	1.8×10^{-7}	-	3.0	-	3.3×10^{-5}
Outer Warm Belt	20	2.0×10^{-5}	-	8.0	-	3.4×10^{-5}
Silicate Ring	35-90	2.0×10^{-4}	+0.01	6.0-23	-3.5	3.0×10^{-5}
Ice Ring	35-90	4.2×10^{-3}	+1.05	100-200	-3.5	4.4×10^{-6}
Silicate Halo	90-110	2.5×10^{-4}	+0.15	15-23	-3.5	4.8×10^{-6}

Model Parameters: (1) Location; (2) Total Mass; (3) Mass surface density exponent; (4) Grain radius; (5) Grains size distribution exponent; (6) Fractional Luminosity.

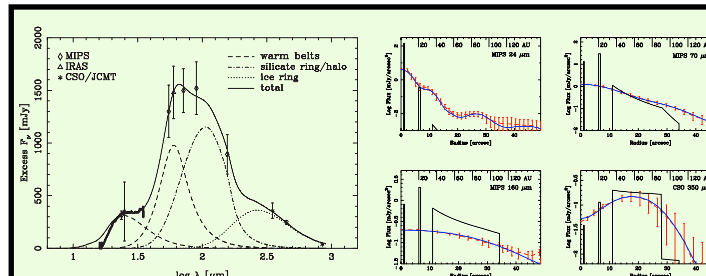
Our Spitzer Space telescope and Caltech Submillimeter Observatory new images and spectra have revealed an unexpected view of the ε Eridani debris disk. We found a complex rings system, characterized by two previously unseen silicate belts located at ~3 and ~20 AU, and a large icy belt between 35 to 110 AU corresponding to the previously known sub-millimeter ring. The gaps between the belts suggest the presence of at least 3 barrier planets capable of maintaining the structural integrity of the belts, one of which could be the 3.4 AU radial velocity planet discovered by Campbell et al. (1988) and Hatzes et al. (2000). The total inferred mass in *detected* grains is ~ 0.4 M_{Luna}, 90% of which is in the large "icy" sub-millimeter ring. This mass can be maintained by collisions of ~11 $M_\oplus$ of parent 10 km-sized bodies, similar to the mass our own Solar System Kuiper belt would have had at the age of ε Eridani, had there not been a prior Late Heavy Bombardment clearing event (e.g. Levinson et al. 2007).



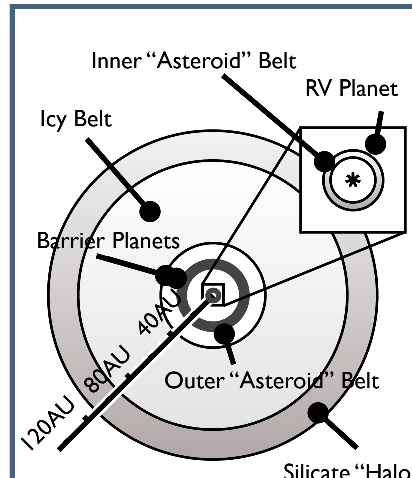
Our SHARCII/CSO 350 μm map shows a structure similar to the sub-millimeter ring discovered by Greaves et al. (1998). Within our sensitivity limits, we do not find evidences of the "clumps" observed in the previous works.



Our Spitzer/MIPS images reveal the presence of warm dust within the central hole of the sub-millimeter ring. This warm material is spatially unresolved at 24 μm and resolved at 70 and 160 μm. The material is also detected in our Spitzer/IRS spectra, characterized by a steep slope between 15 and 25 μm. followed by a plateau between 25 and 35 μm.



Simultaneous fit of both the observed ε Eridani images and spectral energy distribution requires the debris disk to be divided in three separate belts: two narrow warm belts located at ~3 and ~20 AU, and a wide cold ring located between 35 and 110 AU. The two inner belts are characterized by small 3 - 8 μm radius silicate grains (possibly crystalline). The outer belt is made by a mixture of large silicate grains (~ 6 - 20 μm radius) and very large water ice coated grains (100 - 200 μm radius). The icy grains are responsible for most of the sub-millimeter emission; the silicate grains are detected in the IR.



Gaps between the belts may betray the presence of "barrier" planets. One of such planets could be the 3.4 AU Jupiter size body detected with the radial velocity method. The presence of the inner belt constrains a low eccentricity for the orbit of such planet. Two more barrier planets may be required at the edges of the gap between the outer silicate belt and the sub-millimeter ring.

This work will appear on The Astrophysical Journal, January 10, 2009 v690 issue, Backman, Marengo, Stapelfeldt et al.

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