21 Lutetia and other M-type asteroids: Their sizes, albedos, and thermal properties from new IRTF measurements

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This is a modified version of a talk given at the 37th mtg. of the DPS.
M is for Metal

Are M-type asteroids metallic or not?
- Some appear to be metallic (Kleopatra, Psyche),
- some may be non-metallic (Lutetia),
- and some may be both (Antigone, Zwetana).

How do we know?
- reflectance spectroscopy
- radar albedo
- thermal inertia (IRTF observations)
From the observed asteroid thermal continuum we determine the apparent color temperature $T_c$, size, and albedo.
Metallic M-types: 16 Psyche and 216 Kleopatra

16 Psyche: \[ D = 218 \pm 33 \text{ km} \]
\[ p_V = 0.166 \pm 0.050 \]
(IRAS: 253 km!)

216 Kleopatra: ‘D’ = 137 ± 21 km
\[ p_V = 0.182 \pm 0.055 \]
(IRAAS: 135 km)

The thermal inertia in both cases is larger than 50 J m\(^{-2}\) K\(^{-1}\) s\(^{-1/2}\); all other main belt asteroids thermal inertia measurements are 5—25 J m\(^{-2}\) K\(^{-1}\) s\(^{-1/2}\).

So, Psyche and Kleopatra have the
- highest known radar albedo
- highest known thermal inertia consistent with a “metallic” surface.
Non-metallic M-types: 21 Lutetia (Rosetta Target) and 201 Penelope

21 Lutetia:
D = 98.3 ± 5.9 km
p_V = 0.208 ± 0.025
(IRAS: D = 95.8 km, p_V = 0.221)

201 Penelope:
D = 65.8 ± 9.9 km
p_V = 0.173 ± 0.052
(IRAS: 68.4 km)

Neither asteroid displays an elevated thermal inertia.

» So our results are compatible with Rivkin et al. 2000: Lutetia and Penelope are apparently hydrated, i.e. non-metallic.

Lutetia has spectral features similar to those of carbonaceous chondrites. Could Lutetia actually be a C-type? No! Our albedo measurement confirms the IRAS value (p_V = 0.22).
129 Antigone and 785 Zwetana

129 Antigone:  
\[ D = 139 \pm 21 \text{ km} \]  
\[ p_V = 0.156 \pm 0.047 \]  
(not observed by IRAS)

785 Zwetana:  
\[ D = 46.9 \pm 7.0 \text{ km} \]  
\[ p_V = 0.134 \pm 0.041 \]  
(IRAS: 48.5 km)

129 and 785 have radar-dark and radar-bright patches.  

We observed both asteroids twice, at the corresponding rotational phases:

- No significant difference in color temperature (preliminary result)
- No indication for elevated thermal inertia

Thus these asteroids have characteristics of both a regolith-covered and metallic surface.
Conclusions

We have determined the sizes and albedos of 6 M-type main belt asteroids from new mid-IR data.

- The size estimates from IRAS data were mostly confirmed.
- **21 Lutetia (Rosetta fly-by target):** IRAS-albedo seems inconsistent with recent spectroscopic findings, but it is confirmed by our data: $p_V = 0.208$.
- **16 Psyche:** IRAS diameter is slightly too high → previous density estimates are too low.

Furthermore the asteroids’ apparent color temperatures were determined:

- **16 Psyche and 216 Kleopatra** have the highest known thermal inertia in the main belt, consistent with metallic composition.
- The other targets were not found to have an elevated thermal inertia.
- Among M-types, radar albedo may indeed correlate with thermal inertia.