Spectroscopic Observations of Space Debris

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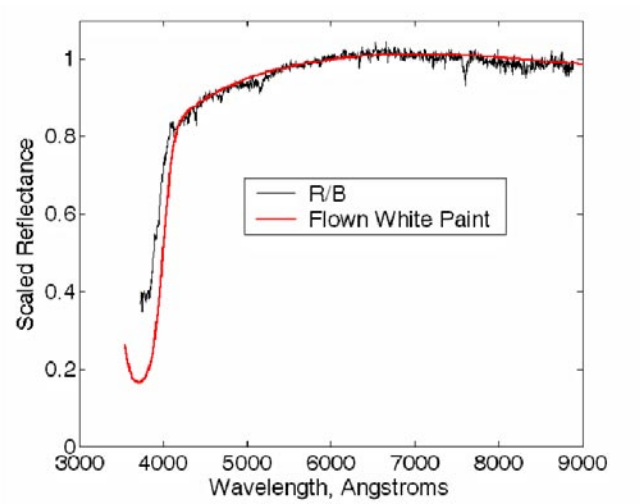
When most people think of orbiting objects, intact operating satellites come to mind. In addition to these operating satellites, there are approximately 10,000 objects in low Earth orbit that are larger than 10 cm in diameter and a much higher number of objects smaller than 10 cm. We can better characterize the space environment if we can determine the physical characteristics of orbiting objects. These properties are used in current space environment models and in designing shields for spacecraft, as well as in providing basic information for predicting the future environment. Some of these characteristics, including material type, are currently assumed. We have shown that it is possible to determine material types of man-made orbiting objects in both LEO and geosynchronous Earth orbit (GEO) using low-resolution reflectance spectroscopy, comparing absorption features and overall shape of spectra.



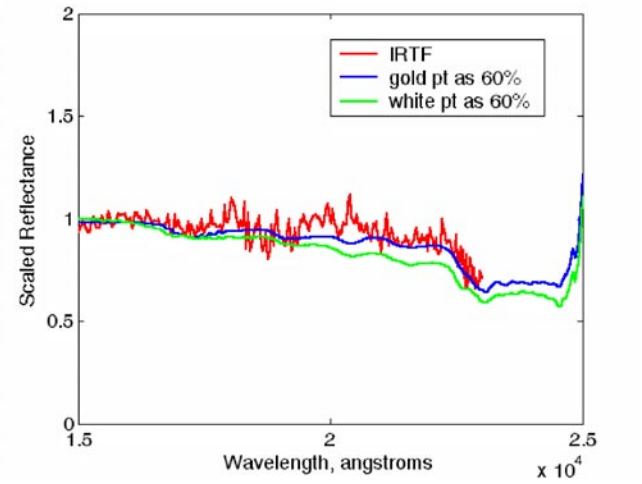
Laboratory Spectrum of White Paint (Red) compared to a remote spectrum of an LEO R/B. The match is very good.

NASS began observations in May 2001 collecting data for eight nights. Since then, data from fifteen additional nights have been collected. Currently, more than 60 rocket bodies (R/Bs) and spacecraft (S/C) spectra have been collected using the 1.6-meter telescope at Air Force Research Laboratory Maui Optical Supercomputing site. The remote spectra were compared to the database of spacecraft material spectra kept at JSC.

Each material type has a different spectrum based on its composition. Figure 1 shows the reflectance spectrum of a LEO R/B (shown in black with more noise) overlaid with a laboratory sample (in red and smoother). The feature near 400 nm is due to white paint. The difference in the wavelength of that feature in the two spectra is due to the difference in temperature between the remote and laboratory sample. Near 840 nm is another dip in the line, a feature due to aluminum. Features like the one from aluminum, unlike the one at 400 nm due to white paint, are harder to distinguish. Thus, we infer the rocket body is made of aluminum coated with white paint.

In addition to determining the material type of orbiting objects, NASS can be used to evaluate the degradation of intact satellites. R/Bs with similar paint schemes will exhibit similar spectral features, but the characteristic reflectance can change with exposure to the space environment.

A puzzling observation from the astronomy community highlights the range of possible uses for the spacecraft materials spectral database. An object thought to be an asteroid, J002E3, was observed in September 2002. Its erratic orbit made astronomers question whether or not it was actually an asteroid. A spectrum, taken at the Infrared Telescope Facility on Mauna Kea, was sent to JSC to see if the spectrum would match human-made materials. Assuming the object might be an upper stage, a model was developed from its known dimensions and paint scheme. The variation between the two models is seen in the kind of white paint used, as seen in Figure 2. This object



IRTF spectrum of J002E3 (in red) as compared with two models of possible paint schemes depending on the kind of white paint used. The comparison shows a good correlation near 1.7 and 2.3 microns where the C-H bands of white paint are seen.

was concluded to be 60% white paint that has turned gold in color due to space environment exposure with the remaining materials being 10% black and 10% yellow paint and 20% exposed metals.

More observations are scheduled using the 1.6-meter telescope at AMOS as well as with the 3.67-meter telescope at the same site. As more observations of R/Bs, intact satellites, large debris fragments, and eventually, smaller debris are accumulated, it will be possible to determine whether the effects of space weathering and other age-dependent factors can be reliably measured with this technique.