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Visible to Near-IR spectroscopy of Basaltic Asteroids in the Inner and Middle Main Belt by the AVAST Survey

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Abstract

The Adler V-Type Asteroid (AVAST) Survey is a program of visible-to-near-infrared spectroscopy of candidate basaltic asteroids in the visible to infrared wavelengths ($0.4 - 2.5$ μm) with the ARC 3.5-m telescope at the Apache Point Observatory. Our targets are selected on the basis of their low ($i - z$) values from observations by the Sloan Digital Sky Survey. To date we have observed 78 asteroids with basalt-like absorption features (0.9 and 2.0 μm), 11 of which have full ($0.4 - 2.5$ μm) coverage. Of particular interest is our observation of 7 beyond the 3:1 mean motion resonance with Jupiter that have spectra consistent with V-type asteroids.

1. Introduction

The presence of a large number of small ($\sim 5-15$ km), apparently basaltic asteroids in the orbital vicinity of Vesta, and bridging the gap between Vesta and the 3:1 mean motion resonance, has been regarded by many as a "smoking gun" linking Vesta to the HED meteorites [1]. Since then, more than one hundred Vesta-like (or V-type) asteroids have been found in the main asteroid belt and among the near-Earth asteroid population (e.g. [10, 7]), including a dynamic family surrounding Vesta that may include almost 4000 known asteroids based off of photometric and dynamic considerations [8].

The discovery of a basaltic asteroid in the outer main belt, (1459) Magnya, that appears to be dynamically unrelated to Vesta [6] has opened the door to studies of the remnants of other differentiated asteroids. Detailed spectroscopic and mineralogical analysis, finds that Magnya is distinct from Vesta in orthopyroxene chemistry, concluding that the compositional difference precludes an origin on Vesta [3]. Other studies have found several additional middle and outer main-belt basaltic asteroids consistent with V-type spectra (c.f. [7] and references within).

The discovery and detailed analysis of basaltic asteroids independent of Vesta can provide insights into the early history of solar system formation, particularly the pattern of heating and differentiation among the terrestrial planetary embryos. The identification of such objects is the major aim of our ongoing observational program, the AVAST (Adler V-Type Asteroid) Survey.

2. Target Selection

Moving objects serendipitously observed during the course of the Sloan Digital Sky Survey (SDSS) have been matched to known objects and cataloged [5, 4]. The Fourth Release of the SDSS Moving Object Catalog (SDSS MOC) contains data on 471,569 moving objects, including astrometric and photometric observations. Of those, 220,101 are linked to 104,449 unique previously known objects [8]. The SDSS filters are able to distinguish the major taxonomic types [4]. In particular, asteroids exhibiting strong 0.9 μm absorption features, such as the V, A, Q, and O taxonomic types, have unusually low ($i - z$) values relative to other asteroids. Since 2005, we have conducted a program of visible-to-near-infrared spectroscopy of candidate V, A, Q, and O-type asteroids using the visible-to-near-infrared Dual Imaging Spectrograph (DIS) and near-infrared TripleSpec instruments on the ARC 3.5-m telescope at the Apache Point Observatory. Our targets are selected on the basis of their low ($i - z$) values in the SDSS MOC, and candiates

3. Results

We have observed 60 main-belt asteroids that display a significant 0.9 μm absorption feature, with 52 of these having spectra consistent with a V-type classification. Our infrared observations with TripleSpec to date consists of 29 main-belt asteroids, of which 11 have matching DIS observations that yield spectral coverage from $0.4 - 2.5$ μm, and allow for the identifi-

cation of both 0.9 and 2.0 μm features, as seen with asteroid 2704 in Figure 1. All targeted asteroids but one show some form of absorption band The only object targeted by the survey that failed to show absorption features had SDSS photometry errors.

4. Basaltic Asteroids beyond 2.5AU

Of particular note are those objects with a > 2.5 AU, i.e., on the other side of the 3:1 mean motion resonance from the Vesta family. Because the strong resonance inhibits the cross-diffusion of asteroids from the Vesta family [9], objects with larger semi-major axes have a greater probability of being independent of Vesta, and are thus of more interest to our program. We independently selected and confirmed a basaltic nature for the middle and outer main belt asteroids 1459, 7472, 10537, and 21238. In addition to these objects, we find that asteroids 105041, 63085, 18745 and 34698 have a strong basalt-like absorption features (0.9 or 2.0 μm), although a rigorous classification of these asteroids remains an ongoing project.

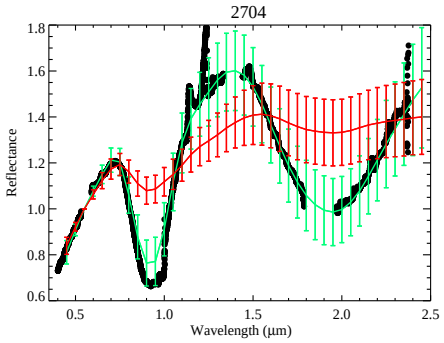

Figure 1: The reflectance spectrum of 2704 (Julian Loewe) in black, with the average V-type (green) and S-type (red) spectra from the Bus-DeMeo taxonomy [2] overlain.

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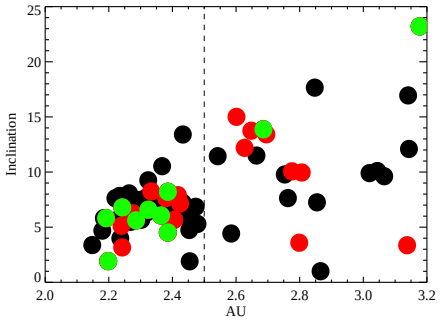

Figure 2: The location of the observed asteroids. Visible spectra in black, IR spectra in red and objects with both are in green.

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