Bering – a deep space mission to study the origin and evolution of the asteroid belt

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An estimated population of approximately 10^{10} main belt asteroids in the size range 1 m to 1 km are too faint to be observed using Earth-based telescopes. Despite their small sizes these asteroids are of considerable interest. Most of the small asteroids are fragments from recent impact events on larger asteroids. Some of the fragments are perturbed out of the main belt and fall on Earth as meteorites. The young surfaces and minimal regolith cover on recently produced fragments makes it possible to relate their spectral signature to those of their corresponding meteorites. Following the trail of fragments back to their parent asteroid will ultimately allow us use the meteoritic evidence to understand the distribution of asteroid types in the main belt and thus shed light on the early evolution of the asteroid belt. Observations of small asteroids are also needed to constrain crater count ages of planetary surface, including ages inferred for the recent climatic evolution of Mars. The vast majority of recent craters on Mars are due to impacts of sub-km asteroids and age estimates therefore rely on poorly constrained estimates of abundance of small objects. Finally, estimating the actual size distribution of small asteroids will allow us to constrain models of the collisional evolution of main belt asteroids.

We propose to detect and study a statistically significant sample of sub-km asteroids using a fully autonomous spacecraft observing from within the asteroid belt. The spacecraft will use a modified ASC (Advanced Stellar Compass) to detect unknown asteroids down to $M_v \approx 13$. Once detected the asteroids will be observed repeatedly using an onboard telescope in order to determine orbit, spectral type, albedo, and, when possible, light curves. The telescope will be able to observe the objects down to $M_v \approx 24$ or approximately to a distance of 60 000 times the detection range.

A critical design parameter is the detection rate of asteroids since the spacecraft will be observing unknown objects from a population, which is also unknown. Using theoretical size distributions of sub-km asteroids we have performed mission simulations in order to estimate detection rates for different sizes of asteroids. The detection rate is controlled by two factors – the limiting magnitude and the tangential velocity of the objects. Meter-sized objects can only be observed at very close range and will therefore in some cases move sufficiently fast that they escape detection. Assuming a circular orbit at 2.5 AU for the spacecraft we find a detection rate of unknown objects of 6/day. With an estimated lifetime of the spacecraft of several years we should expect a total of 5-10000 new objects.

Oral presentation preferred.