ASTEROID LIGHTCURVES SIMULATED WITH A REALISTIC ROUGH-SURFACE SCATTERING MODEL. O. V. Wilkman[1], K. O. Muinonen[1,2] and A. I. Penttilä[1], [1]Department of Physics, University of Helsinki PL 64 00014 Finland (olli.wilkman@helsinki.fi), [2]Finnish Geodetic Institute, Kirkkonummi, Finland

For many asteroids, the only observations we have are photometric lightcurves. The observed disk-integrated brightness depends on the properties of the surface regolith, the shape and orientation of the asteroid, and on the location of the asteroid in the Solar System relative to the Sun and the Earth. Accurate modeling of all the effects which affect the observed brightness is vitally important when trying to learn about the asteroid's properties from the observations.

Traditionally, the Lambertian and Lommel-Seeliger scattering laws have been used to model the light-scattering properties of the asteroid surface. Typically a weighted average of the two are chosen. Neither of these is a truly realistic model for real regoliths, which consist of packed grains of various mineral materials. The structure of the regolith causes a shadowing effect which darkens the surface outside of opposition geometry. Additionally, the small-scale properties of the surface cause a phase-dependent behaviour through effects such as coherent backscattering [1].

We are studying the direct problem of computing lightcurves, using a scattering law derived from light scattering simulation which take into account these effects. Our scattering law is Lommel-Seeliger reinforced with a shadowing function and a phase function.

The shadowing function is computed by a ray-tracing code utilizing our regolith simulation [2]. The simulated medium consists of a large number of spheres, packed into a volume with a given packing density. Additional macro-scale surface roughness is introduced by clipping the volume with a two-dimensional random field with the desired statistical topography.

We use a phase function derived from photometry of lunar mare surfaces [3, 4]. A data set of multi-angular photometry has been derived from photographs of the lunar surface taken by the SMART-1 spacecraft in 2004–2006. Using similar ray-tracing simulations, the shadowing function was reduced out of the data and the phase dependence separated. We take this phase function to be applicable to C-type asteroids which have low albedos.

Figures 1 and 2 show simulated light curves for a convex asteroid shape model, using observational geometries borrowed from real observations of asteroid 21 Lutetia. The lightcurves are calculated using the Lambertian and Lommel-Seeliger scattering laws in addition to our model.

We are in the process of comparing these scattering laws over a range of different asteroid shapes, observational geometries and surface parameters.

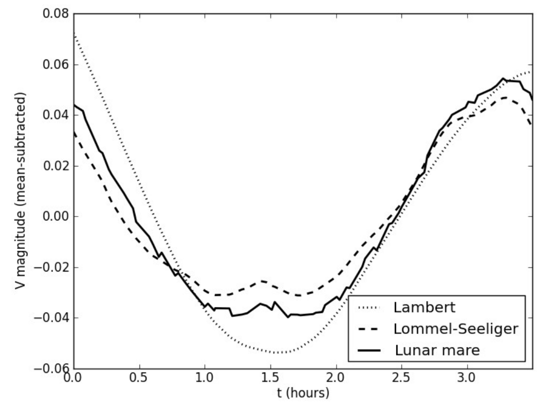

Figure 1: Simulated lightcurves at phase angle 15.5°.

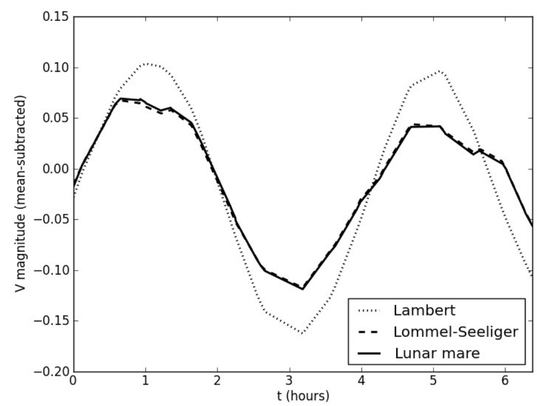

Figure 2: Lightcurves at phase angle 1.8°. Our model approaches the Lommel-Seeliger law at low phase angles.

[1] Muinonen, K. et al., this conference, [2] Parviainen, H. and Muinonen, K., (2009) JQSRT 110, 1418-1440, [3] Wilkman, O (2011), Master's thesis, University of Helsinki, [4] Muinonen, K et al. (2011), A&A, 531, A150.