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# Range of phase integral values for asteroids

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## Abstract

The values of the phase integral were determined for the main asteroid composition types using brightness phase functions in the wide phase angle range from space mission data. We found that the range of phase integral values for asteroids of different composition is within 0.34-0.54 with an average value of 0.42.

## 1. Introduction

The phase integral *q* is a main component for determination of the Bond albedo that enters into the thermal equilibrium equation and used for analyzing data obtained in the infrared wavelength range. Different authors have obtained different estimations of the phase integral of asteroids. Morrison [1] used the value of phase integral *q*=0.6. Later the relationship between *q* and *G* parameter of the *HG*-function [2] was used in [3-5]. Similar relationship has been proposed between *q* and $G_1$, $G_2$ parameters of the $HG_1G_2$-function [6]. The estimations of phase integrals have been made for asteroids using numerical integration of the phase function of brightness from space mission data [7, 8]. Here we investigate how the phase integral depends on asteroid composition types.

## 2. Results

The detailed observations of phase function of asteroid brightness have revealed their similarity within the same compositional types [9]. Based on the average *G*, $G_1$ and $G_2$ parameters for the main compositional types and the proposed relations between *q* and these parameters, the phase integral *q* lies in the range from 0.34 (low-albedo asteroids) to 0.64 (high-albedo asteroids). For some asteroids the phase functions of brightness have been obtained in a wide region of phase angles which allow direct calculation of the phase integral. To obtain the phase function for the S-type we have combined the data for the asteroids 1862 Apollo and 5535 Annefrank [10, 11]. We have obtained the value of *q* equal to 0.44 by the numerical integration. Using the data for the C-type asteroid 253 Mathilda [8, 12] and for the E-type asteroid 2867 Steins [13] we obtained *q* equals to 0.34 and 0.54, respectively. Note, that the value of the phase integral *q*=0.26 of 253 Mathilda given in [8] is smaller compared to our determination. The published values of phase integrals *q*=0.40 for the MU-type asteroid 21 Lutetia [7] and *q*=0.44 for the V-type asteroid 4 Vesta [14] are close to the values for the S-type asteroids. These data show that the range of *q* for asteroids of different types is within 0.34-0.54. The range is smaller as compared to values calculated using the *G* or $G_1$ and $G_2$ parameters [15]. We used the composite phase function of brightness for these asteroids (Fig. 1) to determine an average value of the phase integral.

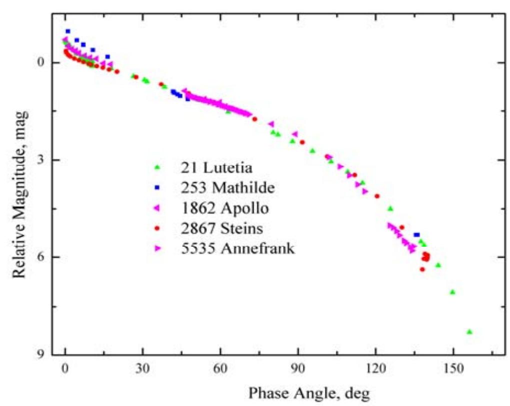


Figure 1: Composite magnitude phase function of asteroids [7, 8, 10-13].

There are differences in magnitude behavior at small and large phase angles, but these differences are substantially less than global brightness changes in the range of phase angles of 0-180 deg. We have obtained the value of $q$=0.42 for the whole data set.

## 3. Conclusions

A range of the values of the phase integral for asteroids of different compositional types lies from 0.34 to 0.54 with an average value of $q$ =0.42. These values can be used for determination of the Bond albedo of asteroids.

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