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Accurate absolute magnitudes for Kuiper belt objects and Centaurs

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Abstract

Accurate absolute optical magnitude values (H_V and H_R) for Kuiper belt objects (KBOs) and Centaurs are becoming increasingly important as observations in other wavelengths, particularly SIRTF thermal infrared measurements, become available for large samples of objects. We present accurate H_V and H_R values for 90 KBOs and Centaurs, based on our published optical photometry. We find that our H_V values are in good agreement with those available from the European photometric survey of minor bodies in the outer Solar System. Comparison with H_V values from the JPL Horizons database and the Minor Planet Center database shows that these sources are systematically brighter than ours by about 0.3 mag.

Keywords: Centaurs; Kuiper belt objects; Trans-neptunian objects

1. Introduction

There are now about 1000 cataloged minor outer Solar System bodies, with about 500 having been observed at more than one opposition. For the vast majority, nothing is known of their intrinsic physical properties. In 1995, we began a large and systematic program to obtain optical (BVR) colors and magnitudes for a sample of these objects. Our program has been aimed at obtaining accurate optical colors and searching for correlations of color with various orbital parameters (see, e.g., Tegler et al., 2003). In addition to optical colors, we have also obtained some information on light curves of individual objects (Romanishin and Tegler, 1999; Romanishin et al., 2001).

For all objects in our sample, we have measured accurate V band magnitudes and V–R colors from at least one epoch. These data can, of course, be used to derive an estimate of the absolute visual magnitudes (H_V) of the objects. The H_V magnitude is one of the most basic observable quantities of a minor Solar System body.

Several groups are using infrared measurements of KBOs and Centaurs, these being obtained with SIRTF, to measure the thermal emission properties of a subset of the population. These observations should yield important new information on the sizes of these objects. Comparison of the infrared and optical fluxes can yield the optical albedo.

To obtain an accurate optical albedo from comparison of optical and infrared observations, an accurate optical absolute magnitude or flux value is required. Because of the increasing importance of accurate values of optical parameters, we present here such information for the objects for which we have published optical photometry. We also compare our derived H_V values with those available from several large databases of properties of minor Solar System bodies.

2. Absolute magnitudes

We use the H, G formalism (Bowell et al., 1989) to derive the absolute visual magnitude (H_V), which is the magnitude that would be observed in the V passband by an observer at

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a distance of 1 AU from an object that is 1 AU from the Sun, at a phase angle of 0°.

We derive H_V from the observed V magnitude, distances, and phase angle:

$$H_V = V - 5\log(r\Delta) + 2.5\log\left[(1-G)\Phi_1(\alpha) + G\Phi_2(\alpha)\right], \quad (1)$$

where V is the measured magnitude of the object in V band, r is the heliocentric distance (in AU) at the time of observation, Δ is the geocentric distance (in AU) at the time of observation, α is the phase angle (Sun–target–observer angle) at time of observation and

$$\Phi_i(\alpha) = \exp\left[-A_i\left(\tan\frac{1}{2}\alpha\right)^{B_i}\right], \quad (2)$$

where $i = 1, 2$, $A_1 = 3.33$, $B_1 = 0.63$, $A_2 = 1.87$, $B_2 = 1.22$.

We assume a G value of 0.15, which is the value most often adopted for this class of objects. Using observations over a range of α, Buie and Bus (1992) derive $G = 0.16$ for (5145) Pholus. Unfortunately, almost all of our observations of individual objects are made at a single epoch, so we cannot constrain G values.

Observed V magnitudes and observation dates were taken from our published papers (Tegler and Romanishin, 1998, 2000, 2003; Romanishin and Tegler, 1999; Tegler et al., 2003). Distances (r and Δ) were derived from the JPL Horizons online database (Giorgini et al., 1996; http://ssd.jpl.nasa.gov/horizons_doc.html). For objects with H_V listed in Romanishin and Tegler (1999), new H_V values were derived for consistency and also to use distances from orbits with any improvements made since that paper. The new H_V values for these objects agree to within 0.01 mag with our previously published values.

Our derived H_V values are listed in Table 1. For the majority of the objects, we have observations taken only during one night, or perhaps a few nights during one observing run. The information in this table is available online at http://observatory.ou.edu/kbos.html. Our color survey is continuing, and we will update the online information as we derive final magnitudes and colors for newly observed objects. For convenience we also list H_R values in Table 1, derived from the H_V values and published V–R colors.

3. Comparison with other sources

Another large photometric survey of minor outer Solar System bodies is available from a collaboration of a number of observers using European Southern Observatory (ESO) telescopes. They present H_V values (Doressoundiram et al., 2002) or H_R values (Peixinho et al., 2004), which we converted to H_V values by adding their V–R color for each object. Ignoring a few objects in these lists with large (greater than 0.1) errors in H_V, we find 30 objects in common with

Table 1
H_V and H_R magnitudes

Number	Name	Prov.	Des.	H_V	H_R
		2003	CO1	9.29	8.80
		2001	XZ255	11.24	10.49
		2001	SQ73	9.24	8.78
		2001	QX322	6.70	6.10
		2001	KG77	8.62	8.18
		2001	KC77	7.23	6.67
		2001	FM194	7.91	7.47
		2000	KK4	6.46	5.82
		2000	FZ53	11.72	11.16
		2000	FS53	7.88	7.17
		2000	CR105	6.60	6.08
		2000	CQ105	6.29	5.85
		2000	CF105	7.59	6.89
		1999	TR11	8.63	7.88
		1999	HV11	7.47	6.88
		1999	HS11	6.88	6.16
		1999	CF119	7.42	6.81
		1998	WX24	6.79	6.09
		1998	WV24	7.43	6.93
		1998	KS65	7.63	6.99
		1998	FS144	7.17	6.60
		1997	SZ10	8.75	8.10
		1997	QH4	7.44	6.77
		1997	CV29	7.71	7.06
		1997	CT29	7.19	6.44
		1996	TS66	6.50	5.74
		1996	TQ66	7.69	6.99
		1996	TK66	6.75	6.12
		1996	RR20	7.20	6.49
		1996	RQ20	7.00	6.56
		1995	HM5	8.29	7.88
		1994	TA	12.05	11.37
		1993	RO	8.92	8.41
		1993	FW	7.09	6.46
95626		2002	GZ32	7.24	6.82
88269		2001	KF77	10.52	9.79
87269		2000	OO67	9.82	9.10
86047		1999	OY3	6.46	6.09
85633		1998	KR65	7.10	6.43
83982		2002	GO9	9.17	8.41
82158		2001	FP185	6.38	5.80
82155		2001	FZ173	6.23	5.68
82075		2000	YW134	4.74	4.19
79360		1997	CS29	5.52	4.91
73480		2002	PN34	8.66	8.14
65489		2003	FX128	6.60	6.04
63252		2001	BL41	11.46	10.95
60621		2000	FE8	6.83	6.35
60608		2000	EE173	8.49	8.00
60458		2000	CM114	7.36	6.86
55636		2002	TX300	3.47	3.11
54598	Bienor	2000	QC243	7.69	7.19
52975	Cyllarus	1998	TF35	8.99	8.24
52872	Okyrhoe	1998	SG35	11.23	10.75
52747		1998	HM151	8.02	7.40
50000	Quaoar	2002	LM60	2.74	2.10
49036	Pelion	1998	QM107	10.54	10.02
47171		1999	TC36	5.33	4.64
44594		1999	OX3	7.85	7.16
42355		2002	CR46	7.65	7.13

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