

UT, obtained 64 images of 60s of exposure in B, V, R and I filters. From our data, we obtained mean colors $B-V=0.74\pm0.02$, $V-R=0.37\pm0.02$ and $R-I=0.45\pm0.02$. Using A. Harris' FAZ routine within the Canopus program to determine asteroid's H-G system parameters (Bowell et al. 1989), based on our V apparent magnitudes at various phase angles (8.9 to 20.4 degrees), we found $H_V = 15.0\pm0.1$ using $G=0.15$. When both values are allowed to "float", the results are $H_V = 14.93\pm0.06$ and $G=0.12\pm0.06$ (fig.2). Both H estimates are consistent with a value of $H = 14.8\pm0.8$ reported in the JPL Small-Body Database Browser. Our mean colors and G value (see Warner, Harris and Pravec., 2009) don't agree with a X-complex member classification for this object. We propose a new classification as a Tholen's C-complex member (GC) and, with more color compatibility, a G type, and we also recommend a search for hydration bands in the visible ($\approx 0.7\mu\text{m}$) and NIR ($\approx 3\mu\text{m}$). (See Rivkin et al. 2001.)

2003 QO104. 2003 QO104 was classified as S type by M. D. Hicks (see Benner, 2009). This object has a synodic rotation period of $114.4\pm0.1\text{h}$ and lightcurve amplitude of $1.60\pm0.04\text{mag}$ (Warner et al. 2009). We observed this object at Salvador in 2009 June 19.99 UT ($\alpha=70.1^\circ$) and obtained 24 images of 40 and 60s of exposure in B, V and R filters. We found $B-V=0.88\pm0.02$ and $V-R=0.45\pm0.02$. Our colors agree with a S or R Tholen type.

2005 RQ6. We observed this object at Mayhill in 2009 November 06.29 UT ($\alpha=12.8^\circ$), and obtained 12 images of 180s of exposure in V, R and I filters. We found $V-R=0.423\pm0.005$ and $R-I=0.33\pm0.02$. Our colors match consistently with a Q Tholen type. Using our data, we found apparent magnitude $V=15.53\pm0.02$ at 07:07 UT. This value has excellent agreement with the Minor Planet Center (MPC) ephemerides value with $<1\%$ error. Using the H-G system and our V apparent magnitude, we estimate a H_V value for 2005 RQ6. Assuming $G=0.2\pm0.1$ (Warner, Harris and Pravec 2009), this yields $H_V=19.22\pm0.05$. This H estimate is consistent with a value of $H = 18.9\pm0.5$ reported in the JPL Small-Body Database Browser. As the mean reduced lightcurve amplitude of an analysed NEA sample is 0.29 mag. (Binzel et al., 2001) and that our H_V isn't a mean value over a whole rotational cycle, we can conclude that our absolute magnitude estimate supports the 2005 RQ6's JPL Small-Body Database's H value.

2005 WJ56. 2005 WJ56 was classified as a X (X_K) type by M. D. Hicks (Benner 2008; Somers et al. 2008) and after as E type by M. D. Hicks and V. Reddy (see Benner et al. 2009) in the context of X type complex (Clark et al., 2004). In our previous work (Betzler et al., 2008), we classified this object as a P type based on its high visible spectral slope and our estimate of H absolute magnitude. In our data processing, we used b and r USNO A2 magnitudes to obtain the Johnson-Cousins B-V, V-R and R-I field star and asteroid colors. However, this b and r magnitude has a typical error of 0.1 mag and with the use of conversion equations to obtain the stars' colors and magnitudes, high random and systematic errors were propagated in our asteroid color indices. Therefore we reanalyze our data obtained in Salvador on 2008 January 08.02 UT ($\alpha=26.1^\circ$). We found $B-V=0.698\pm0.001$, $V-R=0.428\pm0.001$ and $R-I=0.407\pm0.001$. Our colors match with the X-type.

2009 UN3. 2009 UN3 has a synodic rotation period of 4.1h and 0.4 mag. of lightcurve amplitude, reported by Polling et al. and classified as a S type by Hicks, Barajas and Shitanishi (see Benner., 2010). It was observed in Moorook (G9), in 2010 February 05.55 ($\alpha=73.5^\circ$), and 06.58 UT ($\alpha=68.3^\circ$). We obtained 12 images in B and V filters at February 05th and 16 images in

B,V, R and I filters in the second observation session. All images were obtained with 15s of exposure due to the fast angular movement of this object ($>20''/\text{min}$) in order to avoid excessive trailing. In our first observational session, we obtained $V=14.47\pm0.03$ and $B-V=0.771\pm0.009$. On 2010 Feb 06, we obtained $V=14.12\pm0.02$, $B-V=0.771\pm0.005$, $V-R=0.47\pm0.02$ and $R-I=0.266\pm0.005$. The object's colors in the second observational session suggest that the object may be a QR-type, slightly favoring a Q type. Using the H-G system and V apparent magnitudes, we found a mean H_V and diameter, respectively, equal to 18.6 ± 0.1 and $570\pm40\text{m}$. In order to obtain these estimates, we used mean G and albedo of intermediary taxonomic classes as defined by Warner, Harris and Pravec, (2009). Our measured 2009 UN3 colors, absolute magnitude and diameter agree with Hicks et al (2010b) estimates.

Acknowledgments

Thanks to the Vitae Foundation, MCT, IFBA and Institute of Physics of UFBA (IF-UFBA) by the supporting to "Discovering the Sky" and "Astronomy in the Campus" projects. We thank Mrs. Maria da Gloria Brandão de Santana for authorization of use of our old observation site in Salvador. We are also grateful to R. P. Binzel for many suggestions which much improved this work.

References

- Benner, L. A. M. (2008). "2005 WJ56 Planning". http://echo.jpl.nasa.gov/asteroids/2005WJ56/2005WJ56_planning.html
- Benner, L. A. M. (2009). "(143651) 2003 QO104 Goldstone Radar Observations Planning". http://echo.jpl.nasa.gov/asteroids/2003QO104/2003QO104_planning.html
- Benner, L. A. M., Ostro, S. J., Magri, C., Nolan, M. C., Howell, E. S., Giorgini, Jon D., Margot, J. L., Busch, M. W., Shepard, M. K. P., Taylor, A. and Jurgens, R. F. (2009). "Near-Earth Asteroid Surface Roughness Depends on Compositional Class". <http://echo.jpl.nasa.gov/~lance/scoc/scoc.html>
- Benner, L. A. M. (2010). "2009 UN3 Goldstone Radar Observations Planning". http://echo.jpl.nasa.gov/asteroids/2009UN3/2009UN3_planning.html
- Betzler, A. S., Novaes, A. B., Villa Nova, T. J. C., and Santos, D. (2008). "Colors of Potentially Hazardous Asteroids 2005 WJ56 and 2007 TU24". *Minor Plan. Bull.* **35**, 108-109.
- Binzel, R. P., Lupishko, D., Di Martino, M., Whiteley, R.J. and Hahn, G.J. (2002). "Physical Properties of Near-Earth Asteroids". In *Asteroids III* (W. F. Bottke et al., eds), University of Arizona Press, Tucson, Arizona, pp. 255-271.
- Bowell, E., Hapke, B., Domingue, D., Lumme, K., Peltoniemi, J., and Harris, A. W. (1989). "Application of photometric models to asteroids". in *Asteroids II* (Binzel et al., eds), University of Arizona Press, Tucson, Arizona, pp. 524-556.
- Clark, B.E., Bus, S.J., Rivkin, A.S., Shepard, M.K., and Shah, S. (2004). "Spectroscopy of X-Type Asteroids". *Astron J.* **128**, 3070-3081.

Dandy, C. L., Fitzsimmons, A., and Collander-Brown, S. J. (2003). “Optical colors of 56 near-Earth objects: trends with size and orbit”. *Icarus* **163**, 363-373.

Gary, B.L. (2006). “CCD Transformation Equations for use with Single Image (Differential) Photometry.”
http://reductionism.net.seanic.net/CCD_TE/cte.html

Gary, B.L. (2008). “J and K to BVRcIc: Method #0”.
<http://brucegary.net/dummies/method0.html>

Hicks, M. and Lawrence, K. (2009). “Planetary Radar Targets 1999 AP10, 2000 TO64, 2000 UJ1 and 2000 XK44: Four S-Complex near-Earth Asteroids”.
<http://www.astronomerstelegam.org/?read=2323>

Hicks, M., Barajas, T., Somers, J., Shitanishi, J., and Mayes, D. (2010). “217807 (2000 XK44): “Broad-band photometry of a slowly rotating near-Earth asteroid”.
<http://www.astronomerstelegam.org/?read=2371>

Hicks, M., Barajas, T., Somers, J., and Shitanishi, J. (2010b). “Broadband colors and rotation lightcurves of the Potentially Hazardous Asteroid 2009 UN3”.
<http://www.astronomerstelegam.org/?read=2449>

Lazzarin, M., Marchi, S., Magrin, S. and Licandro, J. (2005). “Spectroscopic investigation of near-Earth objects at Telescopio Nazionale Galileo”. *MNRAS* **359**, pp. 1575-1582.

Rivkin, A. S., Howell, E. S., Vilas, F., and Lebofsky, L. A. (2002). “Hydrated Minerals on Asteroids: The Astronomical Record”. In *Asteroids III* (W. F. Bottke et al., eds), University of Arizona Press, Tucson, Arizona, pp. 235-253.

Somers, J. M., Hicks, M. D. and Lawrence, K. J. (2008). “Optical Characterization of Planetary Radar Targets”. American Astronomical Society, DPS meeting #40, #28.21

Warner, B. D. (2007). “Initial Results of a Dedicated H-G Project”. *Minor Plan. Bull.*, **34**, 113-119.

Warner, B.D., Harris, A.W. and Pravec, P. (2009). “The asteroid lightcurve database”. *Icarus* **202**, 134-145.

Warner, B. D., Stephens, R., D., and Carbognani, A. (2009). “Analysis of the Slow Rotator (143651) 2003 QO104”. *Minor Plan. Bull.*, **36**, 179-180.

Site	Telescope	CCD Detector	Filters
Salvador	0.30m Meade LX200 f/3.3 (with focal reducer)	SBIG ST-7XME	Custom Scientific BVRI
Mayhill	0.30m f/11.9 Takahashi Mewlon (GRAS G1)	FLI IMG1024 DM Dream Machine	Optec BVRI
Moorook	RCOS 0.41m f/8.4.(GRAS G6)	SBIG STL-1001E	RGB
Moorook	RCOS 0.32m f/6.3 (GRAS G9)	SBIG ST-8 NABG	BVRI

Table I. Summary of Instrumentation.

Object	B-V	V-R	R-I	Classification (Tholen)
1999 AP10	0.859±0.002	0.459±0.001	0.395±0.002	S
2000 TO64	Not Measured	0.485±0.003	0.379±0.03	S
2000 UJ1	Not Measured	0.474±0.002	0.381±0.005	S
2000 XK44	0.87±0.03	0.481±0.006	0.27±0.01	R
2001 MZ7	0.74±0.02	0.37±0.02	0.45±0.02	G
2003 QO104	0.88±0.02	0.45±0.02	Not Measured	S or R
2005 RQ6	Not Measured	0.423±0.005	0.33±0.02	Q
2005 WJ56	0.698±0.001	0.428±0.001	0.407±0.001	X
2009 UN3	0.771±0.005	0.47±0.02	0.266±0.005	Q

Table II. Summary of this work’s NEA’s color indices and likely taxonomic classifications.

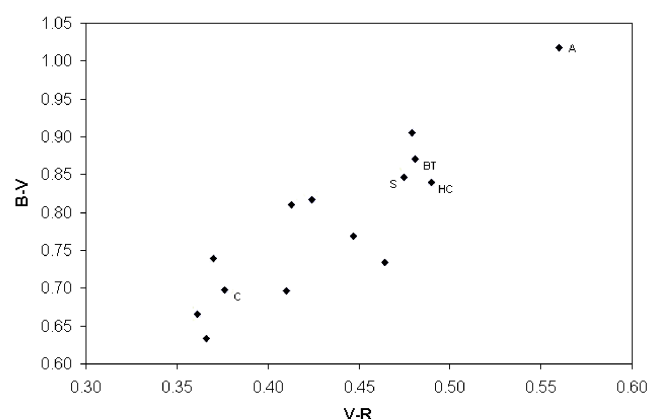


Figure 1. Plot of the B-V versus V-R of typical Tholen taxonomic types colors and the colors obtained in this work (BT) and by Hicks et al. (2010) (HC) for 2000 XK44. “S”, “A” and “C” are, respectively, the S, A and C types mean colors, with typical uncertainties of +/- 0.03 mag.

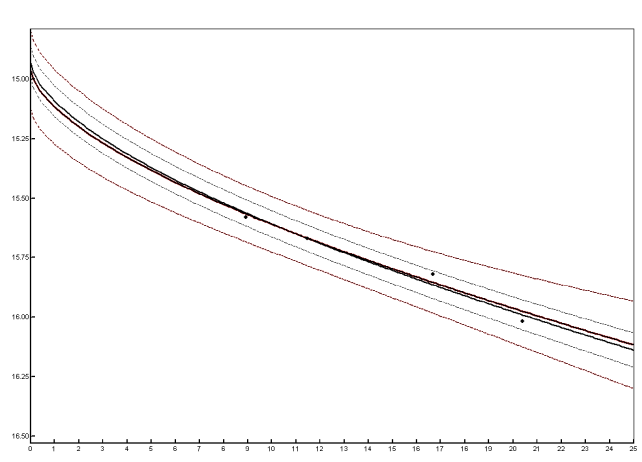


Figure 2. Plot of the reduced magnitude of 2001 MZ7 versus the phase angle. The solid black line corresponds to a curve with $G=0.12\pm0.06$ and the red line to $G=0.2(0.15)\pm0.2$. The reduced magnitudes have ~ 0.01 mag. of error.