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Variability with WISE

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Abstract. WISE mapped the entire sky in four bands during its approximately 7-month cryogenic mission. The number of exposures for each point on the sky increased with ecliptic latitude, and ranged from ∼12 on the ecliptic to over 1000 at the ecliptic poles. The observing cadence is well suited to studying variable objects with periods between ∼2 hours to ∼2 days on the ecliptic, with the maximum period increasing up to several weeks near the ecliptic poles. We present the method used to identify several types of variables in the WISE Preliminary Release Database, and the mid-IR light curves of several objects. Many of these objects are new, and include RR Lyr, Algol, W UMa, Mira, BL Lac and YSO-type variables, as well as some unknown objects.

Keywords. surveys, stars: variables

1. Introduction

The Wide-field Infrared Survey Explorer (WISE) mapped the entire sky in four bands centred at wavelengths of 3.4, 4.6, 12 and 22μ (referred to as W1, W2, W3, and W4, respectively). WISE conducted its survey using a 40-cm cryogenically cooled telescope equipped with four 1024×1024 infrared array detectors that simultaneously imaged the same $47' \times 47'$ field-of-view on the sky. WISE flew in a 531-km sun-synchronous polar orbit and employed a freeze-frame scanning technique whereby the telescope scans the sky continually at a rate of approximately 3.8 arcmin/sec and a scan mirror freezes the sky on the focal plane detectors while 7.7 sec (W1 and W2) and 8.8 sec (W3 and W4) exposures are acquired. The FOV of each successive exposure set overlaps the previous one by 10%, and the scan paths on adjacent orbits overlap by approximately 90% on the ecliptic (see Fig. 1). The WISE survey strategy alternated stepping the scan path forward and backward on subsequent orbits, in an asymmetric pattern that approximately matched the orbital precession rate. In this way, each point near the ecliptic was observed on every other orbit, approximately each 191 minutes, and typically 12 independent exposures were accumulated for each point near the ecliptic. The number of exposures increases with ecliptic latitude, reaching over 1000 at the ecliptic poles.

2. Variable Source Identification

Flux variables were identified through the statistics made while generating WISE multi-frame coadditions. The primary identification method uses the cross-correlation coefficients between the flux measurements in adjacent bands. Objects with band correlation significance $> 70\%$ and with no artifact flags are considered strong candidates. Variable candidates are also found by using the standard deviation of the flux measurements and the maximum difference between uncontaminated flux measurements. The χ^2 statistic was computed for those two quantities, yielding the probability that the source was inconsistent with the reference distribution. The majority of the sources identified by that method are periodic variables. A Lomb-Scargle periodogram was computed for them,

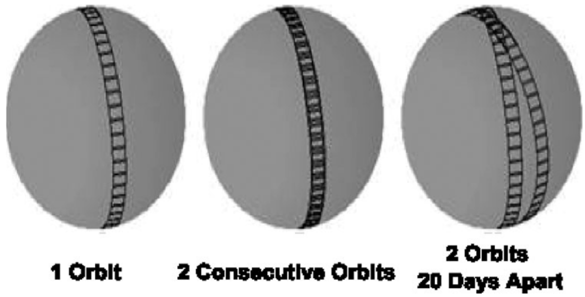

Figure 1. The WISE survey strategy.

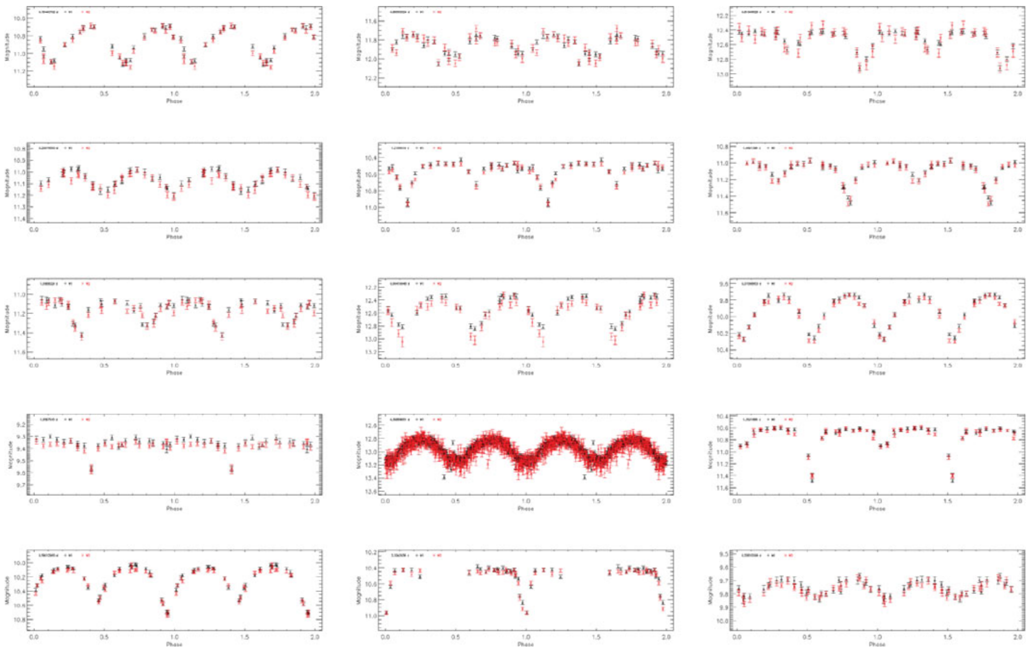

Figure 2. Various types of periodic variables in the WISE data set, phased to the peak power of the Lomb-Scargle periodogram. Example types include W Uma, RR Lyr, Algol, and β Lyr.

and the light curve was phased to twice that period (assuming that most of the periodic variables are eclipsing/rotational variables). Non-periodic variables were also found, but were less numerous.

3. Statistics of Variables

At a preliminary estimate, about 0.5% of all WISE sources are classified as significantly variable in flux. Similar surveys in the optical produce variability rates of 2.0–4.0%. The lower rate is probably due to the fact that the mid-infrared emission from common variables such as W UMa stars is low, as well as having relatively few observations near the ecliptic. The amplitudes of flux variations also tend to decrease at longer wavelengths for many pulsating variables. Nonetheless, a wide variety of variables has been identified with WISE, with W UMa, RR Lyr and Algol systems being the most common. Fig. 2 shows a sample of phased light curves, while Fig. 3 shows the light curves of five long-period variables. The next step is to classify those objects into variability class according to colour, period and light-curve morphology.

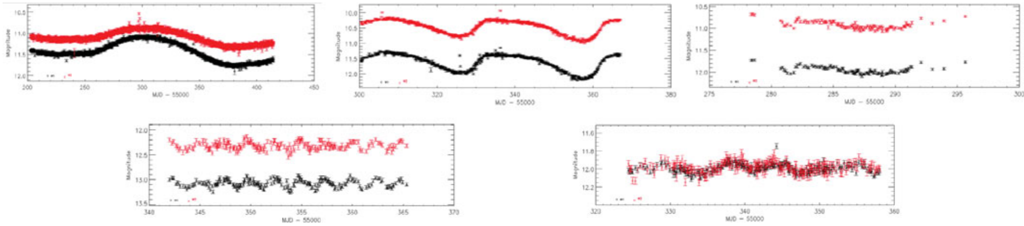

Figure 3. Examples of long-period and irregular variables. These mostly come from the ecliptic polar regions where coverage is greater. The top row features a Mira variable, a Cepheid and a BL Lac object. The bottom row features a young stellar objects with semi-regular variations, and a variable of unknown type.

4. Acknowledgements

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