



# A USNO Search for Astrometric Companions to Brown Dwarfs III



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TABLE II. PRELIMINARY ASTROMETRY OF SELECTED BROWN DWARFS

Brown Dwarf (2MASS J)	Spectral Type	Ref.	Absolute Parallax (mas)	Relative Proper Motion (mas yr <sup>-1</sup> )	Position Angle (deg)	Tangential Velocity (km s <sup>-1</sup> )
19010601+4718136	T5.0	1	...	...	...	...
22425317+2542573	L3	1	...	...	...	...
22443167+2043433	L7.5	1	...	...	...	...
22541892+3123498	T4	1	...	...	...	...
13464634-0031501	T6		72.74 ± 5.02	491.5 ± 10.0	254.31 ± 0.58	32.0 ± 2.3
144600.60+002452.0 <sup>a</sup>	L5		45.46 ± 3.25	191.2 ± 7.0	110.06 ± 1.05	19.9 ± 1.6
16241436+0029158	T6		86.85 ± 3.85	374.0 ± 6.0	269.65 ± 0.46	20.4 ± 1.0
17580545+4633099	T6.5	1	...	...	...	...
21241387+0059599	T5	1	...	...	...	...
22552907-0034336	L0:		16.19 ± 2.59	179.9 ± 2.6	191.61 ± 0.41	52.7 ± 8.7

REFERENCES: Unless otherwise noted values are from Vrba *et al.* 2004; (1) Faherty *et al.* 2009  
NOTE: <sup>a</sup>Name prefix is SDSS J, i.e. SDSS J144600.60+002452.0

### Parallaxes and Proper Motions

- Preliminary results
- baselines ≤ 2.03 years
- X solution only for parallax
- limited reference frames
- Mean error of unit weight for dithered triplets
- 9 ± 3 mas in X (Right Ascension)
- 10 ± 3 mas in Y (Declination)

TABLE III. OBSERVATIONS OF SELECTED BROWN DWARFS

Brown Dwarf (2MASS J)	Observations		Baseline			
	Begin	End	(yr)	Plates	Nights	Filter <sup>a</sup>
19010601+4718136	SEP 2003	JUN 2006	2.75	128	95	J
22425317+2542573	JUL 2004	NOV 2005	1.31	65	38	H
22443167+2043433	SEP 2002	NOV 2005	3.17	145	90	H
22541892+3123498	NOV 2002	NOV 2005	3.02	98	74	J
13464634-0031501	FEB 2001 <sup>b</sup>	JUN 2006	5.35	248	187	J
144600.60+002452.0 <sup>c</sup>	FEB 2001 <sup>b</sup>	JUN 2006	5.35	164	104	H
16241436+0029158	MAR 2001 <sup>b</sup>	JUN 2006	5.22	150	122	J
17580545+4633099	JUL 2004	JUN 2006	1.88	34	31	J
21241387+0059599	JUL 2004	NOV 2005	1.32	101	89	J
22552907-0034336	OCT 2000 <sup>b</sup>	NOV 2005	5.11	235	153	H

NOTES: <sup>a</sup>Broadband filters H (1.6 μm) and J (1.2 μm) per Elias *et al.* (1982)  
<sup>b</sup>2001 observations dates shifted by 1 day to account for minor bug in pipeline software, full reprocessing planned  
<sup>c</sup>Name prefix is SDSS J, i.e. SDSS J144600.60+002452.0

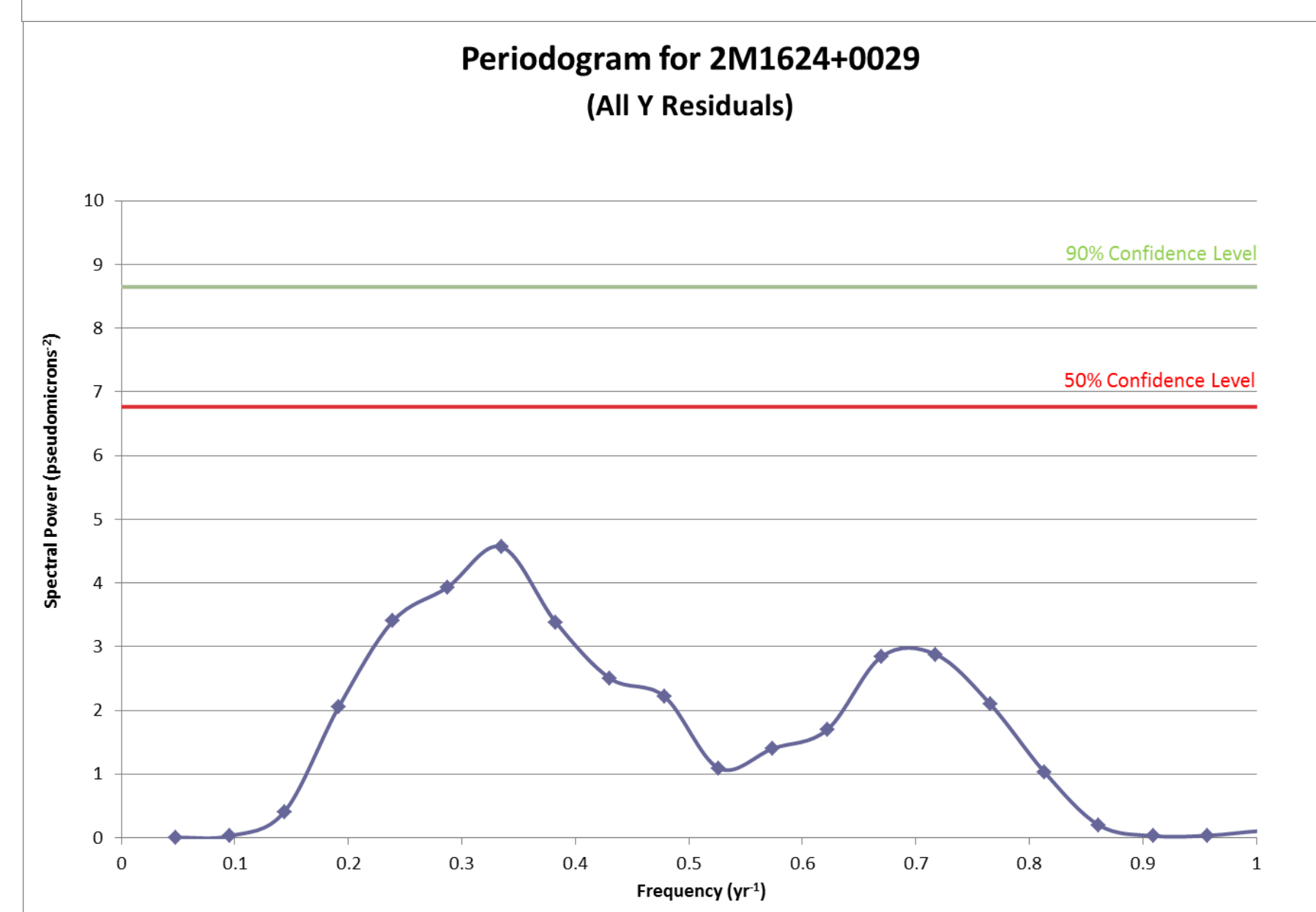
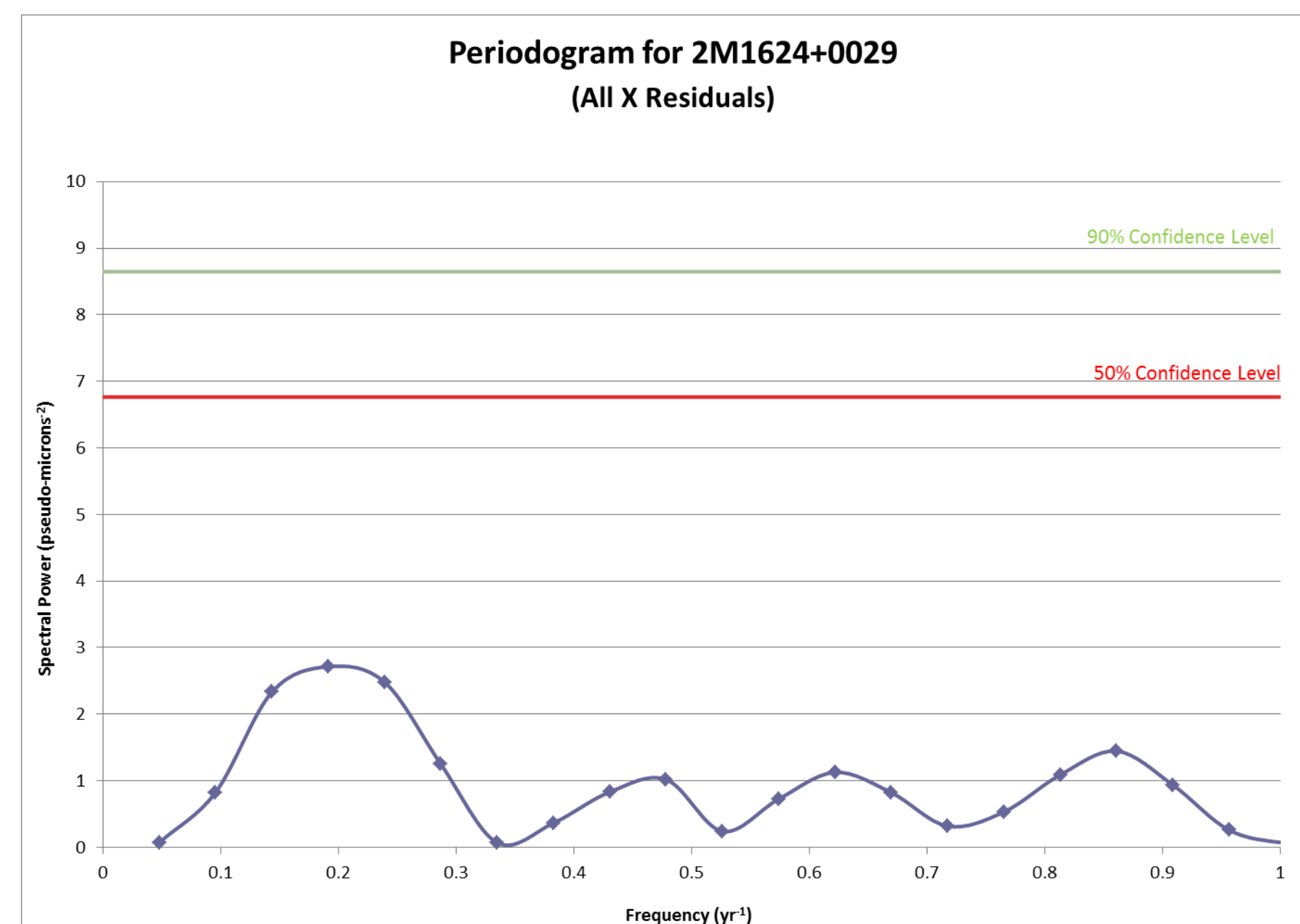


Figure 4. Periodograms for 2MASS J16241436+0029158

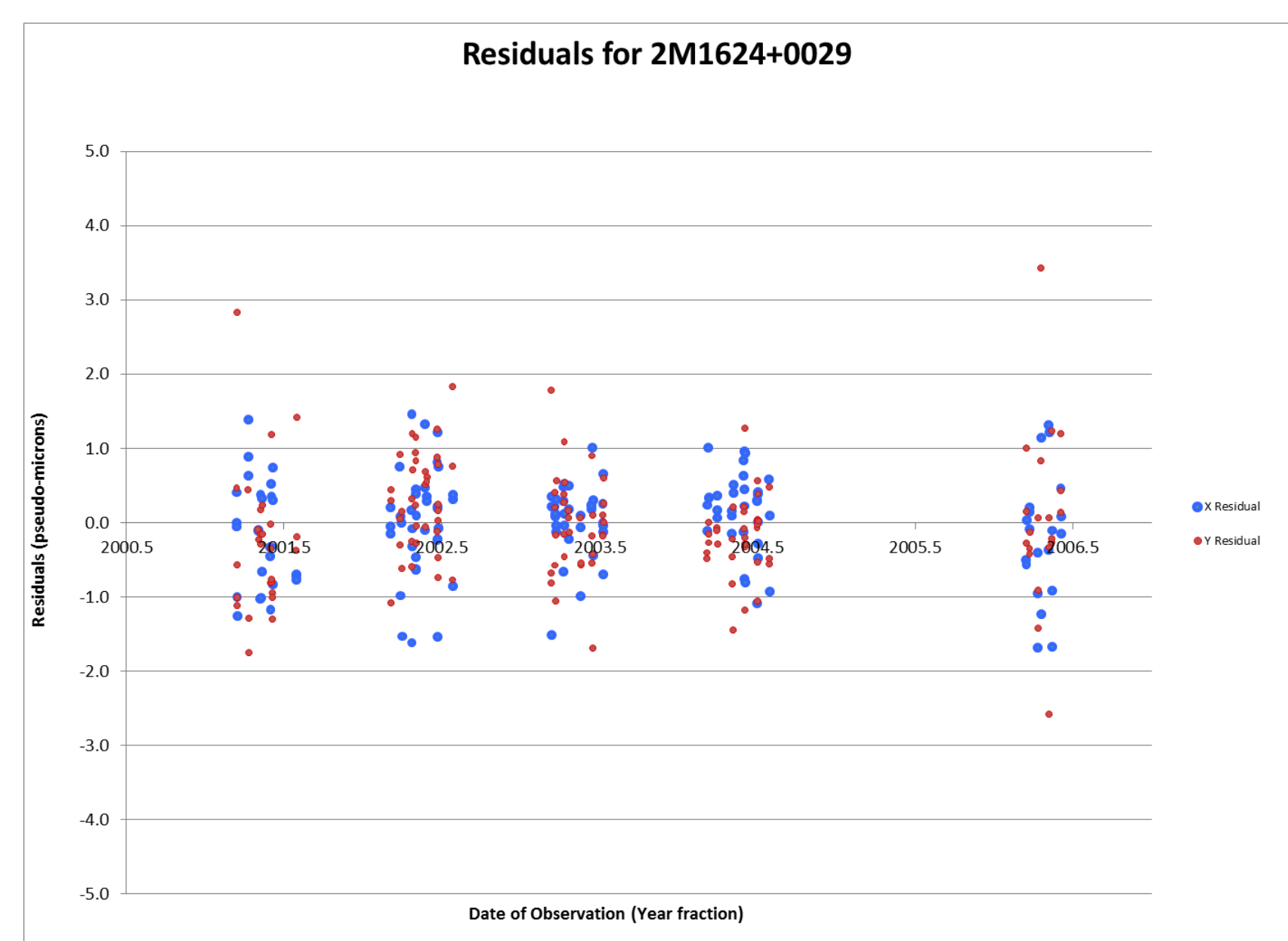


Figure 5. Residuals for 2MASS J16241436+0029158

### Results

10 brown dwarfs tested for possible astrometric perturbations due to low-mass companions

- Selection criteria
- Declination—north of -25°
- Spectral type—early L, mid-T
- Large parallax—all but 2 within 25 pc
- Not known to be binaries

None shows indication of companions, typical examples shown

Minimum detectable companions vary with brown dwarf mass and distance and with quality of observations, estimates in Table IV

Analysis of 19 additional brown dwarfs planned; 20 similar brown dwarfs reported last year (Bartlett *et al.* 2012a, 2012b)

### REFERENCES

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Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. 1992, *Numerical Recipes in FORTRAN 77* (2nd ed; Cambridge Univ. Press), 569-577

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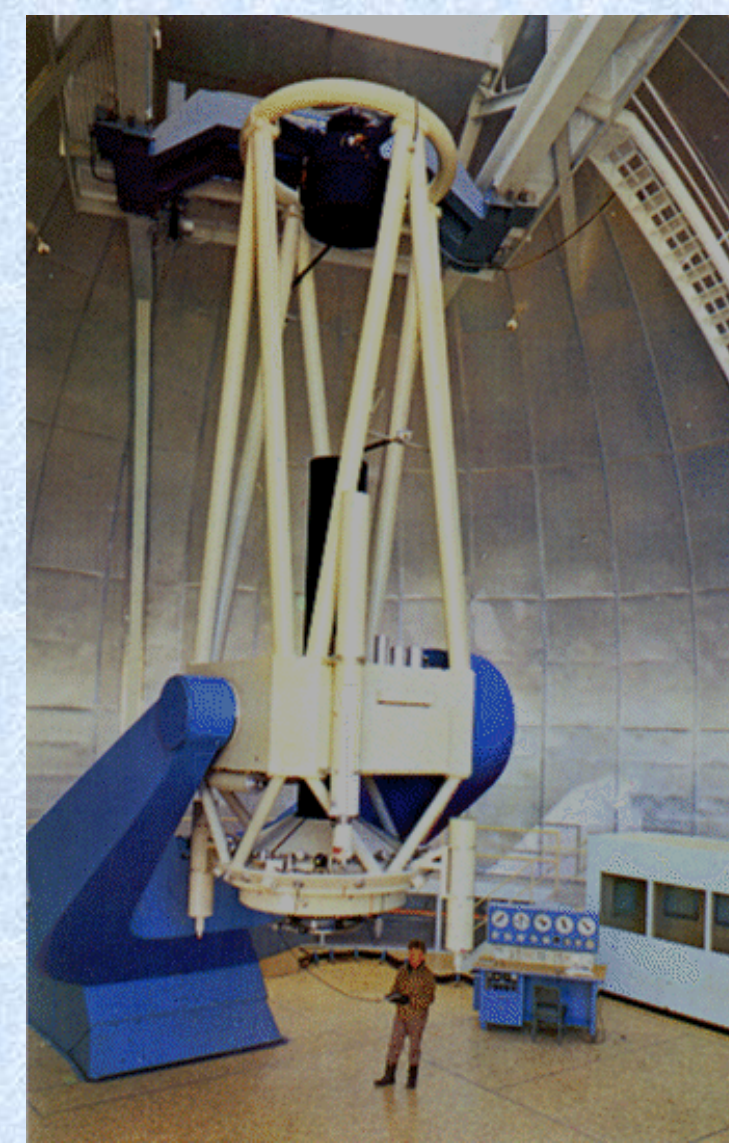


Figure 1. Kaj Strand Astrometric Reflector

TABLE I. REFLECTOR CHARACTERISTICS

Parameter	Description
Objective	1.55 meter (61 inches), f/9.8
Detector	ALADDIN 1024 <sup>2</sup> InSb array 27-μm pixels
Plate Scale	0.3654" pixel <sup>-1</sup> 13.55 mas μm <sup>-1</sup>
Broadband Filters	Z, J, H, K, K', K-long, & L'

### Method

USNO infrared parallax program

- Uses ASTROCAM infrared imager with 1.55-m Kaj Strand Astrometric Reflector at Flagstaff Station, Figure 1 and Table I
- Reduces observations using standard solution for parallax and proper motion, Table II (Vrba *et al.* 2004)

Selected brown dwarfs

- Observed 1.3–5.4 years, Table III
- L dwarfs in H band
- J dwarfs in J band
- Parallaxes and proper motions measured (Vrba *et al.* in prep.)
- Residuals to each observation analyzed
- x- and y- coordinates treated separately
- Time-series analysis per Lomb periodogram method (Press *et al.* 1992)
- Frequencies up to 4x Nyquist frequency searched
- Periodograms prepared using
- Individual observations
- Nightly averages

### ACKNOWLEDGEMENTS

This research made use of the NASA's Astrophysics Data System Bibliographic Services; the M, L, and T dwarf compendium housed at DwarfArchives.org, which is maintained by C. Gelino, J. Kirkpatrick, and A. Burgasser; the SIMBAD database and the VizieR catalog access tool, both operated at CDS, Strasbourg, France; and the Very-Low-Mass Binaries Archive housed at www.vlmbinaries.org, which is maintained by N. Siegler, C. Gelino, and A. Burgasser.

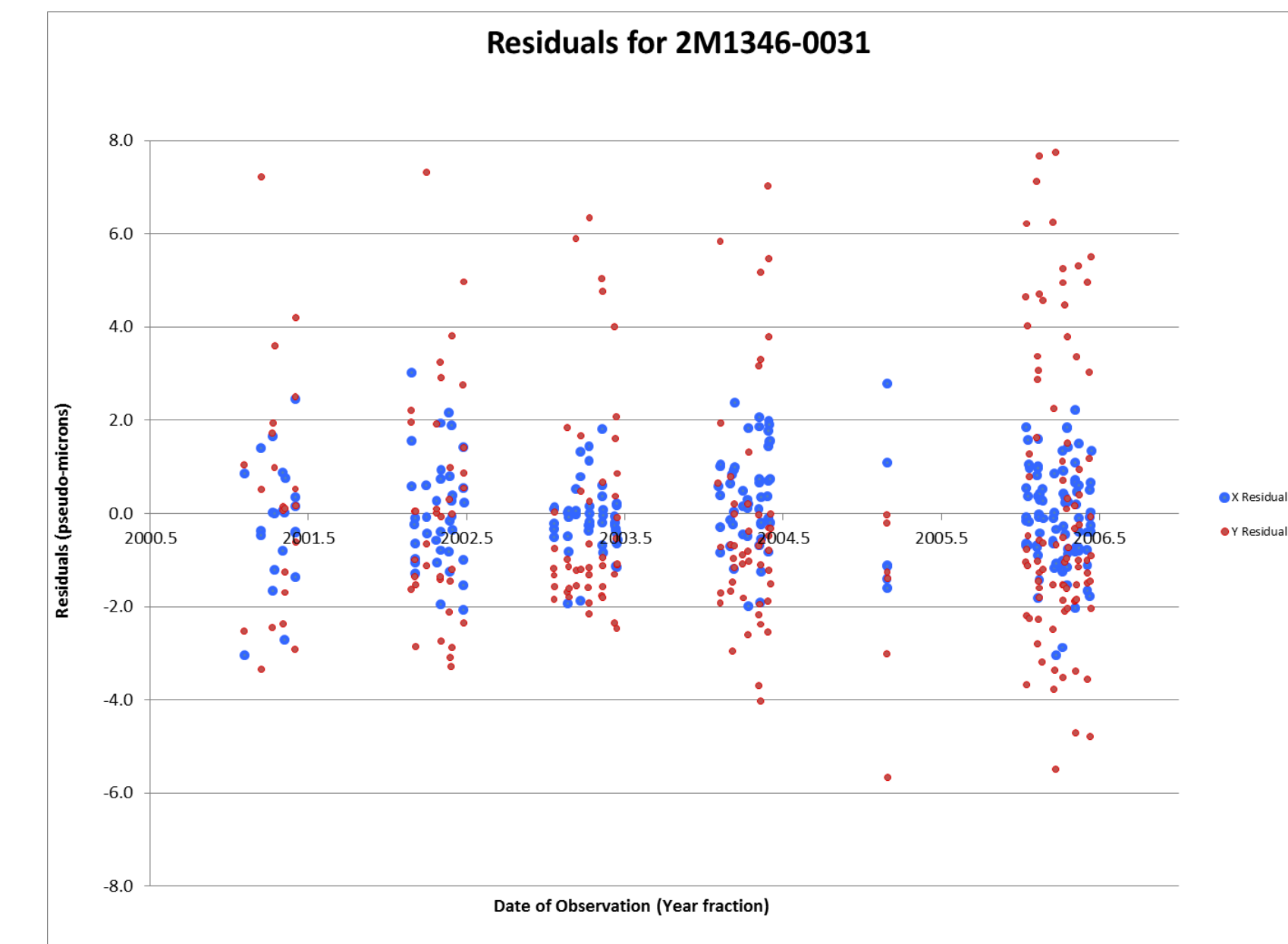


Figure 2. Residuals for 2MASS J1346463-0031501

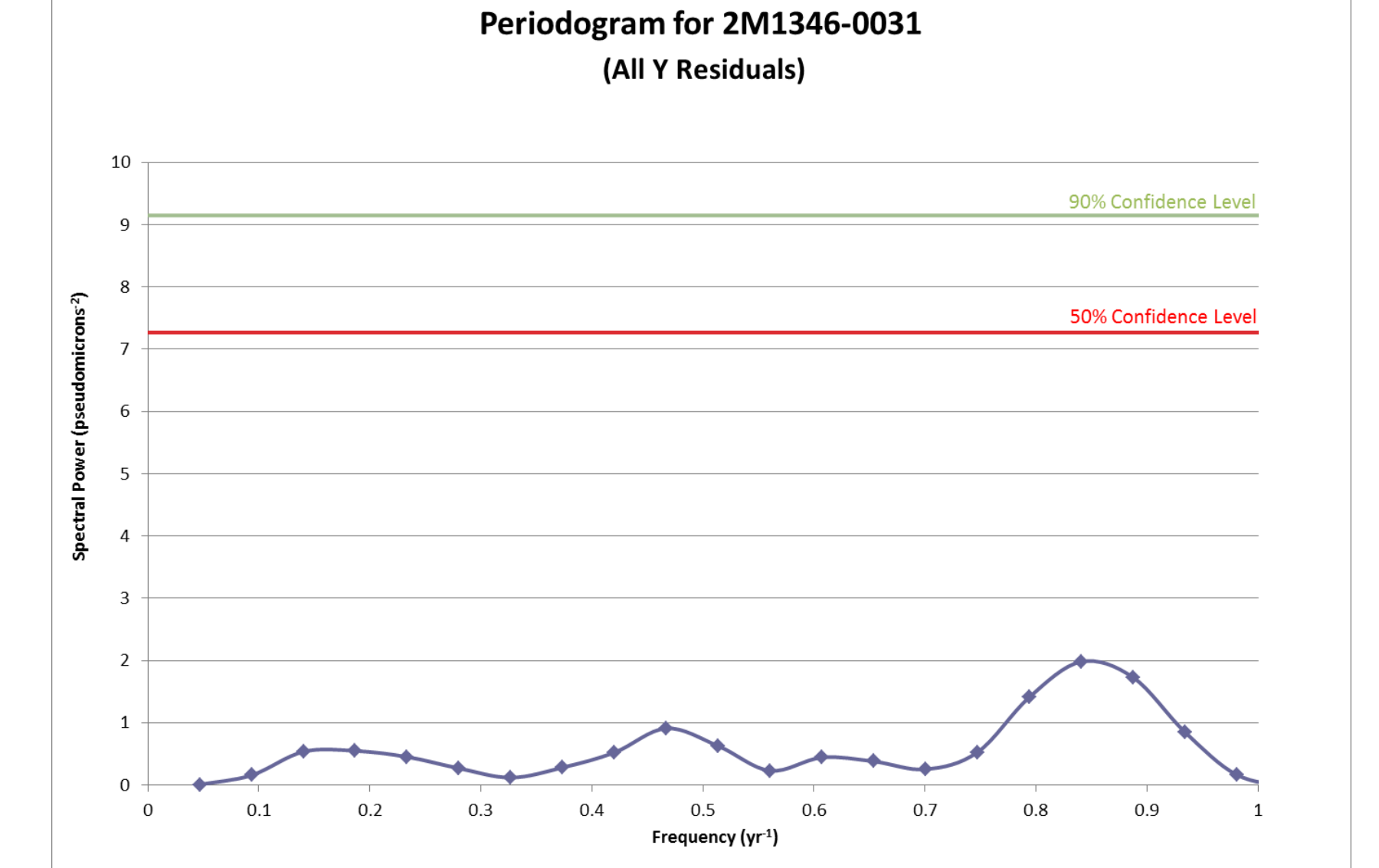
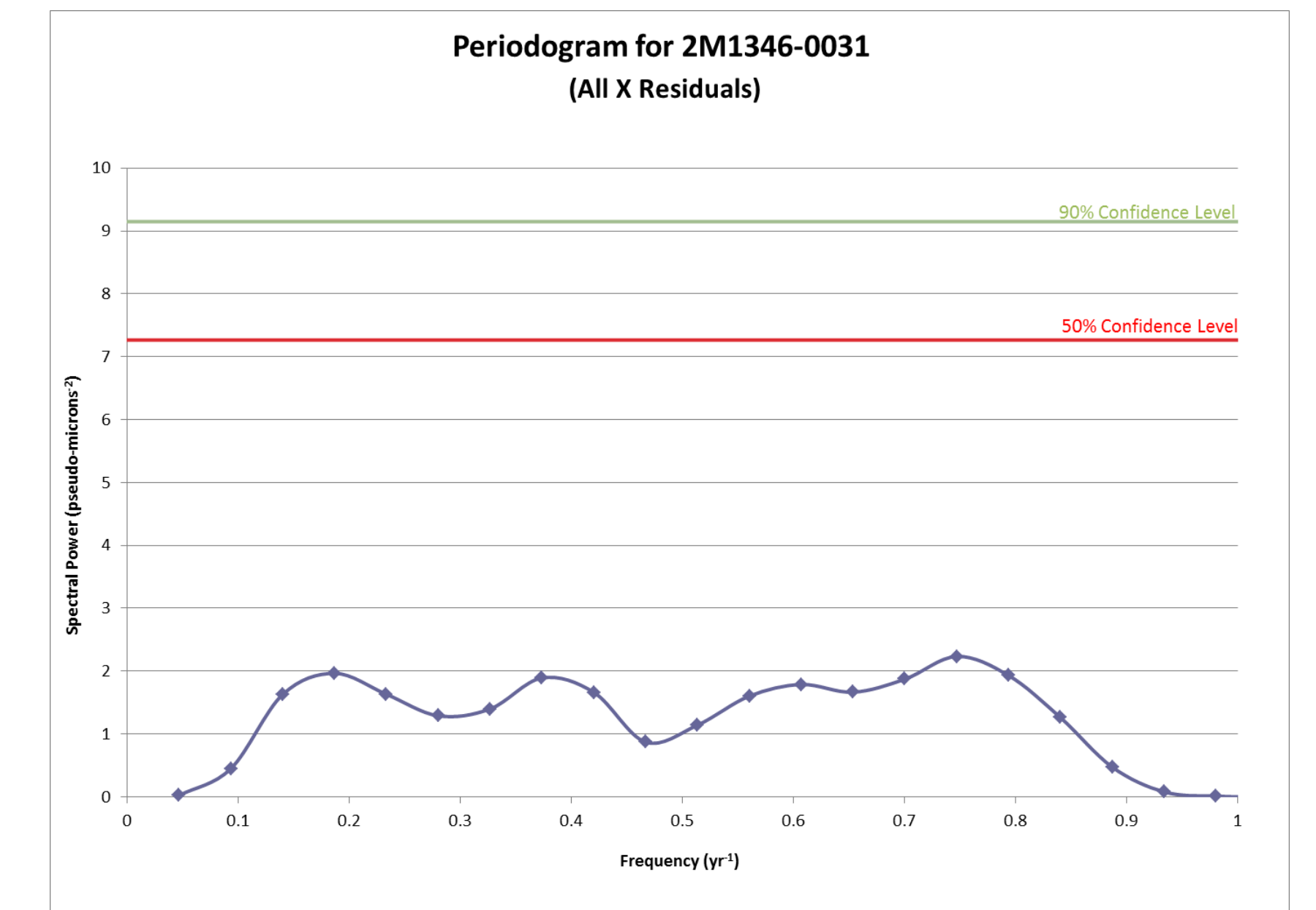


Figure 3. Periodograms for 2MASS J1346463-0031501

### 2MASS J1346463-0031501—Not much happening

- Late T dwarf within 15 parsecs
- No signal ≥ 50% possibility of being real for any frequency searched, similar with nightly residuals
- Minimum detectable companion: ~24 M<sub>Jup</sub> in 1.5-yr orbit or ~10 M<sub>Jup</sub> in 6-yr orbit

### What if a companion were present?

- Significant peaks in both x- and y-residual spectra at same frequency; similar peaks with nightly averages
- Table IV estimates minimum detectable perturbation for each brown dwarf and associated mass for a long-period companion
- Spectral type and parallax per Table II; spectrophotometric distances (Faherty *et al.* 2009) used if no parallax available
- Detectable perturbation ≈ 92% average residual (Bartlett 2007; Bartlett, Ianna, & Begam 2009)
- Estimated mass from spectral type and very-low-mass-binaries archives (Siegler, Gelino, & Burgasser 2009, www.vlmbinaries.org)
- Longest period considered ≈ observational baseline (Table III)

TABLE IV. MINIMUM DETECTABLE COMPANIONS

Brown Dwarf (2MASS J)	Spectral Type	Absolute Parallax (mas)	Detectable Perturbation (mas)	Estimated Mass (M <sub>Sun</sub> )	Long Period (yr)	Companion Mass (M <sub>Jup</sub> )
19010601+4718136	T5.0	...	8	0.05	2.75	8
22425317+2542573	L3	...	7	0.07	1.31	28
22443167+2043433	L7.5	...	10	0.06	3.17	14
22541892+3123498	T4	...	7	0.05	3.02	6
13464634-0031501	T6	72.74	18	0.04	5.35	10
144600.60+002452.0 <sup>a</sup>	L5	45.46	10	0.06	5.33	12
16241436+0029158	T6	86.85	7	0.04	5.22	3
17580545+4633099	T6.5	...	9	0.04	1.89	9
21241387+0059599	T5	...	11	0.05	1.32	22
22552907-0034336	L0:	16.19	10	0.07	5.11	37

NOTE: <sup>a</sup>Name prefix is SDSS J, i.e. SDSS J144600.60+002452.0

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