Variability “Profiles” for T Tauri Variables and Related Objects, from AAVSO Visual Observations

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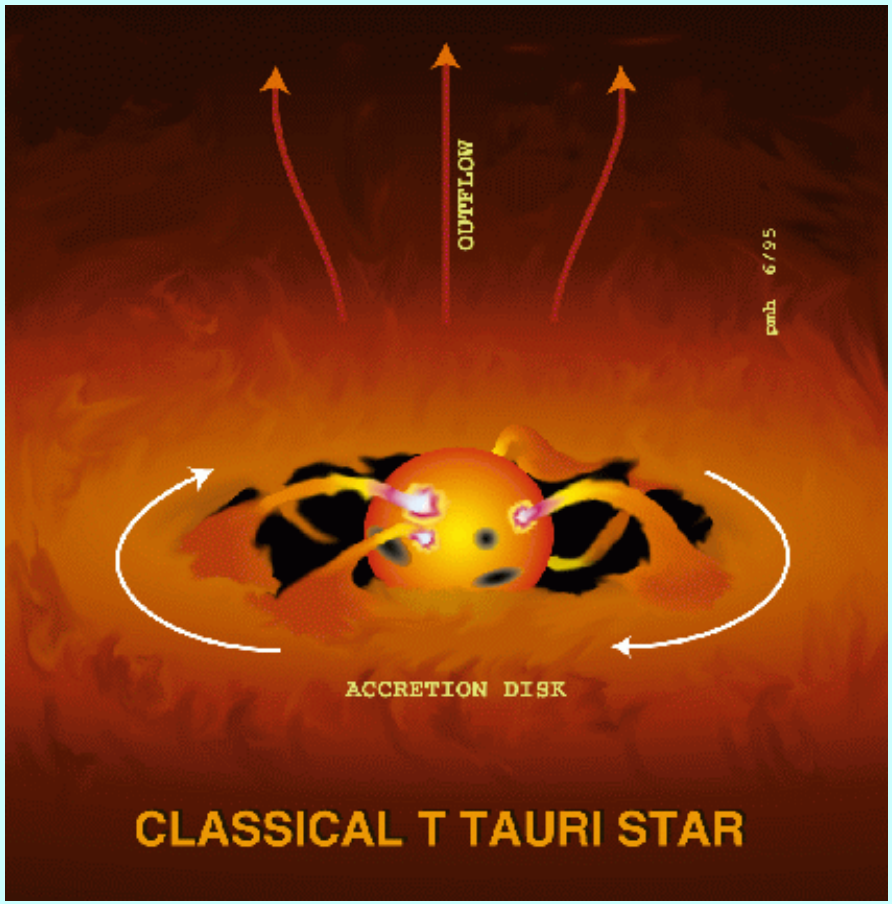
Outline

- T Tauri stars and their variability
- Previous analysis of CCD and visual observations
- Data and methods of analysis
- Results, spurious and otherwise
- Discussion and conclusions
- Acknowledgements, and educational dimensions

T Tauri Stars



- Young stellar objects in various stages of birth, with or without an accretion disc
- Defined spectroscopically: various emission lines; lithium line present

Nature and Cause of their Variability

- Strict periodicity (periods 0.5 to several days) due to rotation of a spotted star; the amplitude varies on time scales of years because of starspot cycles.
- Rapid flickering due to accretion onto the star.
- Slow variation due to variation in the rate of accretion.
- Possible quasi-periodic variation due to effects of a companion, or inhomogeneities in the accretion disc.
- **Study of the variability provides information on star formation processes (e.g. accretion) and properties (e.g. rotation, companion stars, brown dwarfs, or planets).**

Herbst Variability Classes

Reference: Herbst et al. 1994, AJ 108, 1906

- CTTS: classical T Tauri stars: have accretion discs
- WTTS: weak-lined T Tauri stars: accretion disc is no longer visible
- GTTS: G-type T Tauri stars
- HAEBE: Herbig Ae/Be stars: more massive analogues to T Tauri stars
- FUORs: FU Orionis stars: have long-lasting photometric brightenings

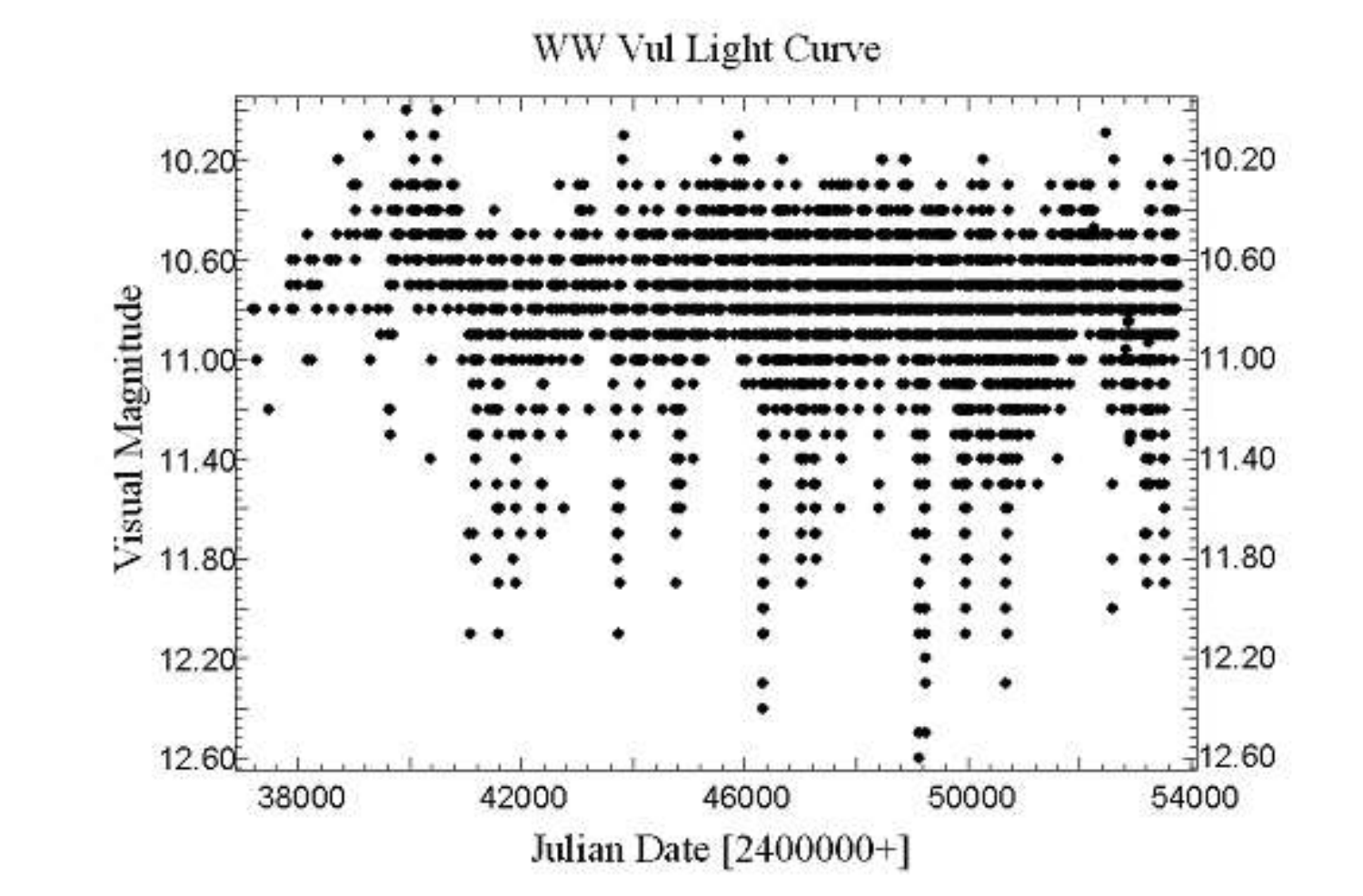
Some Previous Related Studies

- Bill Herbst (Wesleyan University) and his students and other collaborators have amassed long-term CCD photometry of hundreds of T Tauri and related stars, and have used Fourier analysis to study them
- Percy, Gryc, Wong, and Herbst (2006 PASP 118, 1390) showed that self-correlation analysis is a useful adjunct technique for time-series analysis; Percy, Grynko, and Seneviratne (2009, submitted) have extended this work
- AAVSO visual observers have measured T Tauri stars for several decades, but the data were only recently validated; Percy and Palaniappan (2006 JAAVSO 35, 290) showed that these data have scientific value.
- AAVSO HQ has now validated visual measurements of more stars

Source of Data

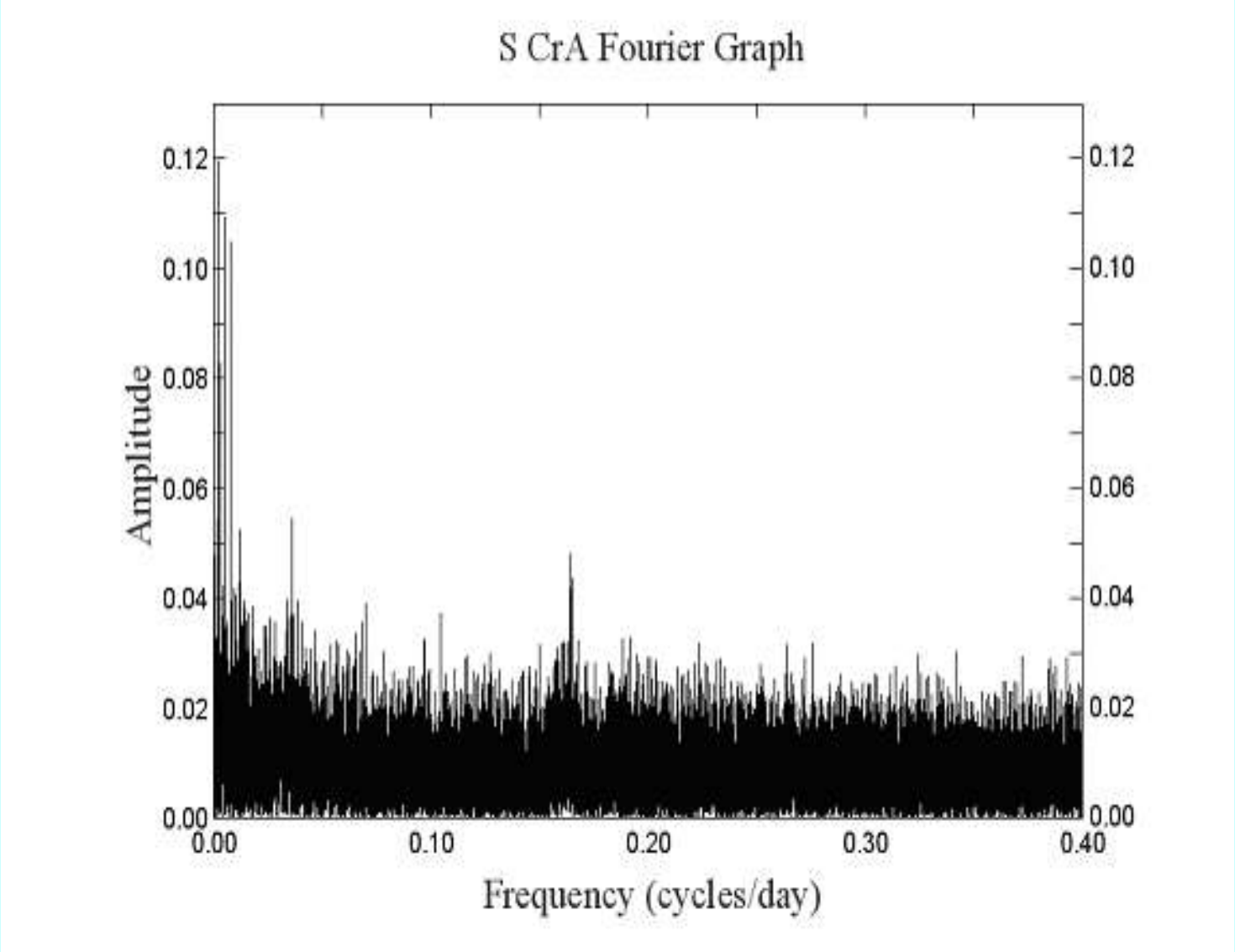
AAVSO International Database

Visual Observations



Methods of Analysis: Fourier Analysis

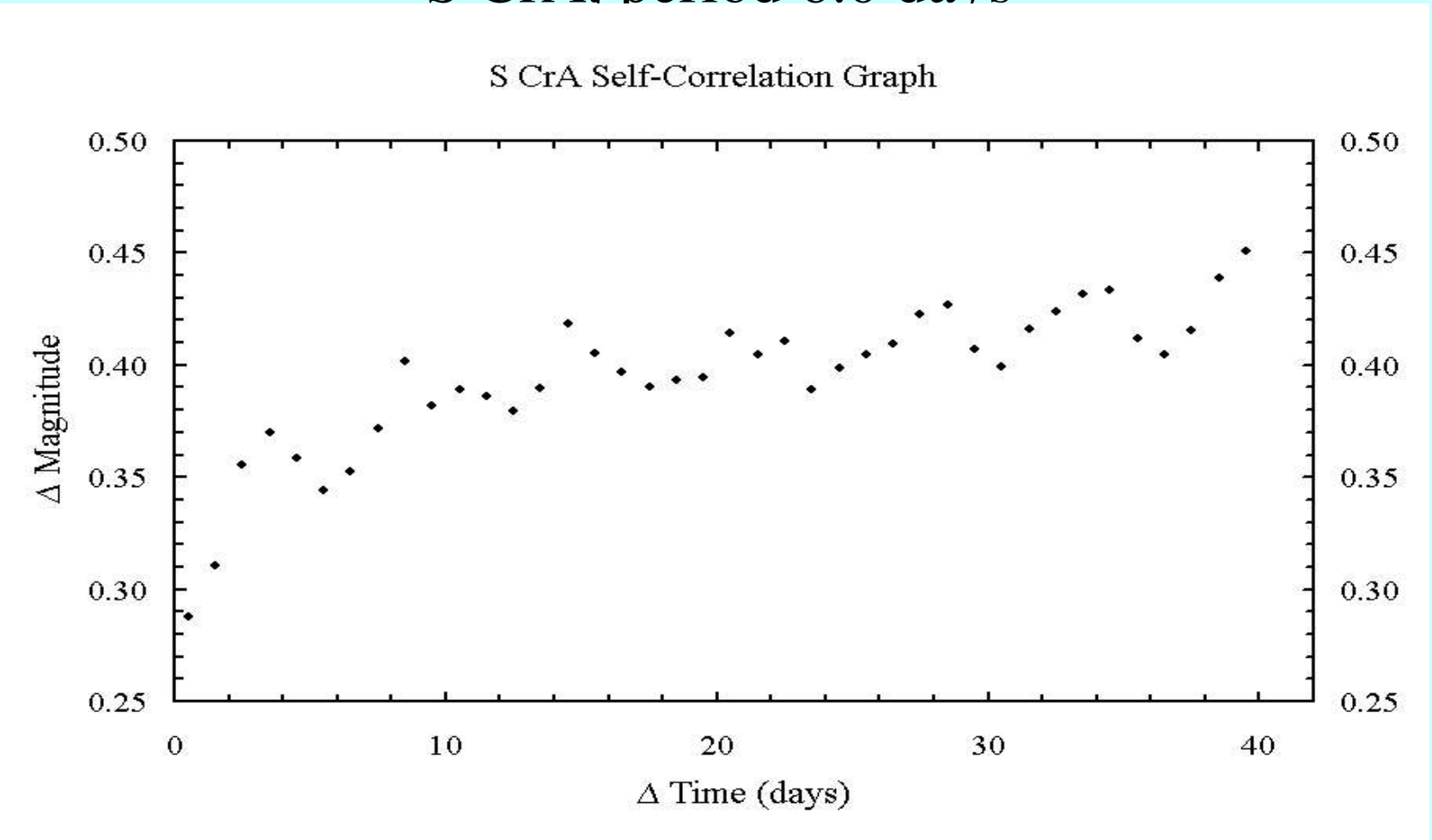
Period04: S CrA, period 6.0 days



Methods of Analysis: Self-Correlation

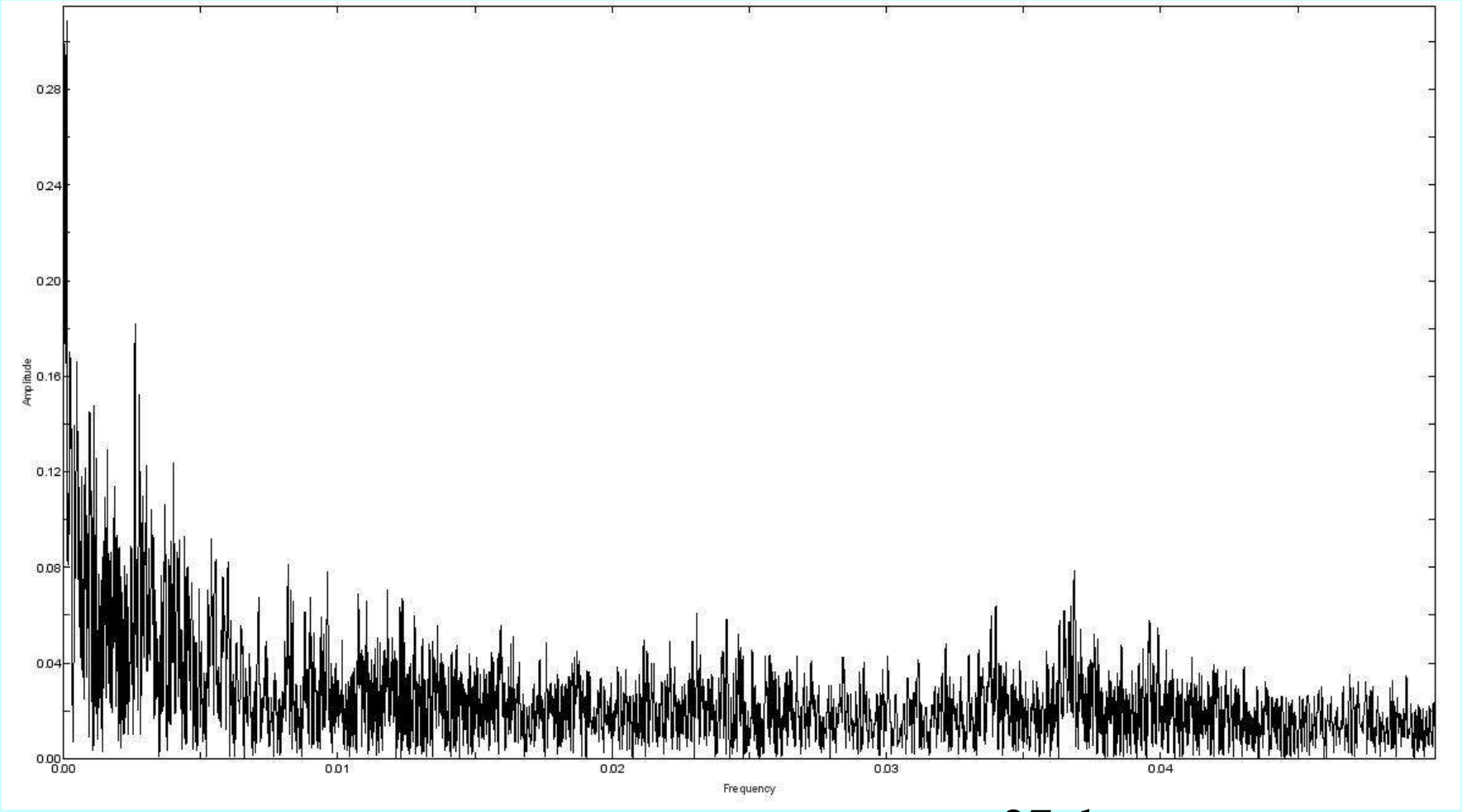
www.astro.utoronto.ca/~percy/students.html

S CrA, period 6.0 days



Results: RY Tau

Spurious One-Month and One-Year Periodicity?

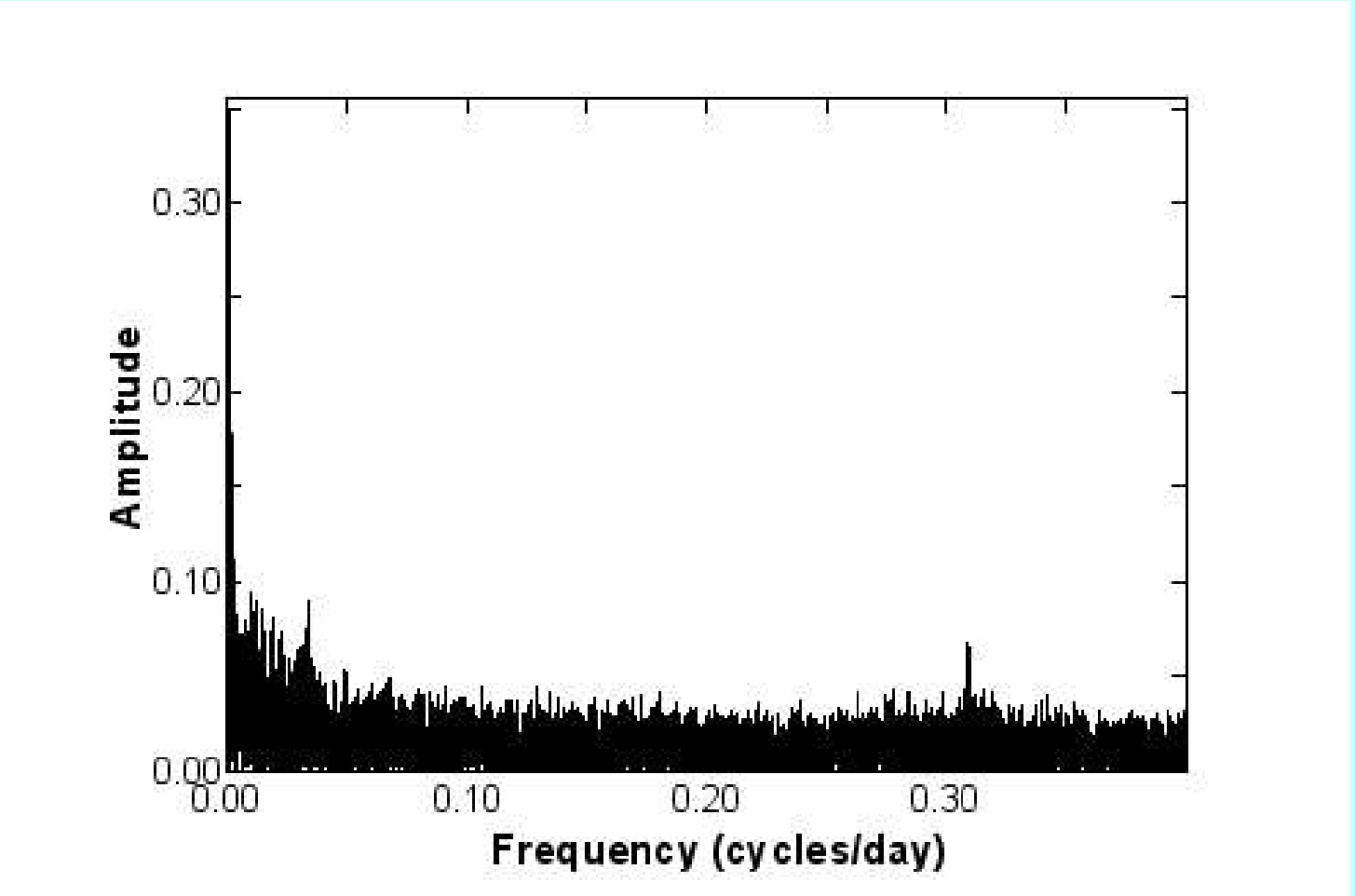


27 days

0.0 Frequency (cycles/d) 0.05

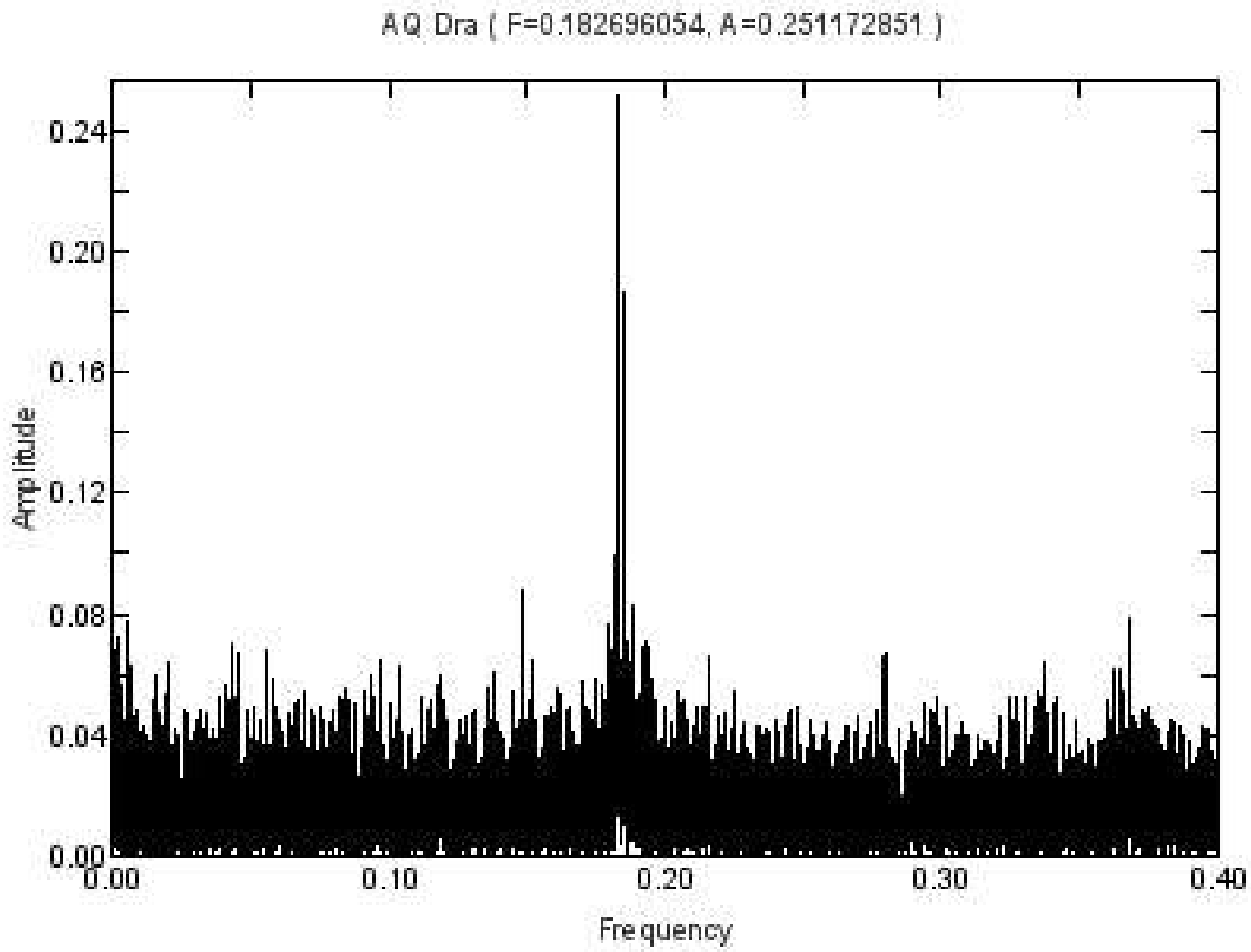
Results: T Cha

Spurious One-Year and One-Month Periodicity?



Results

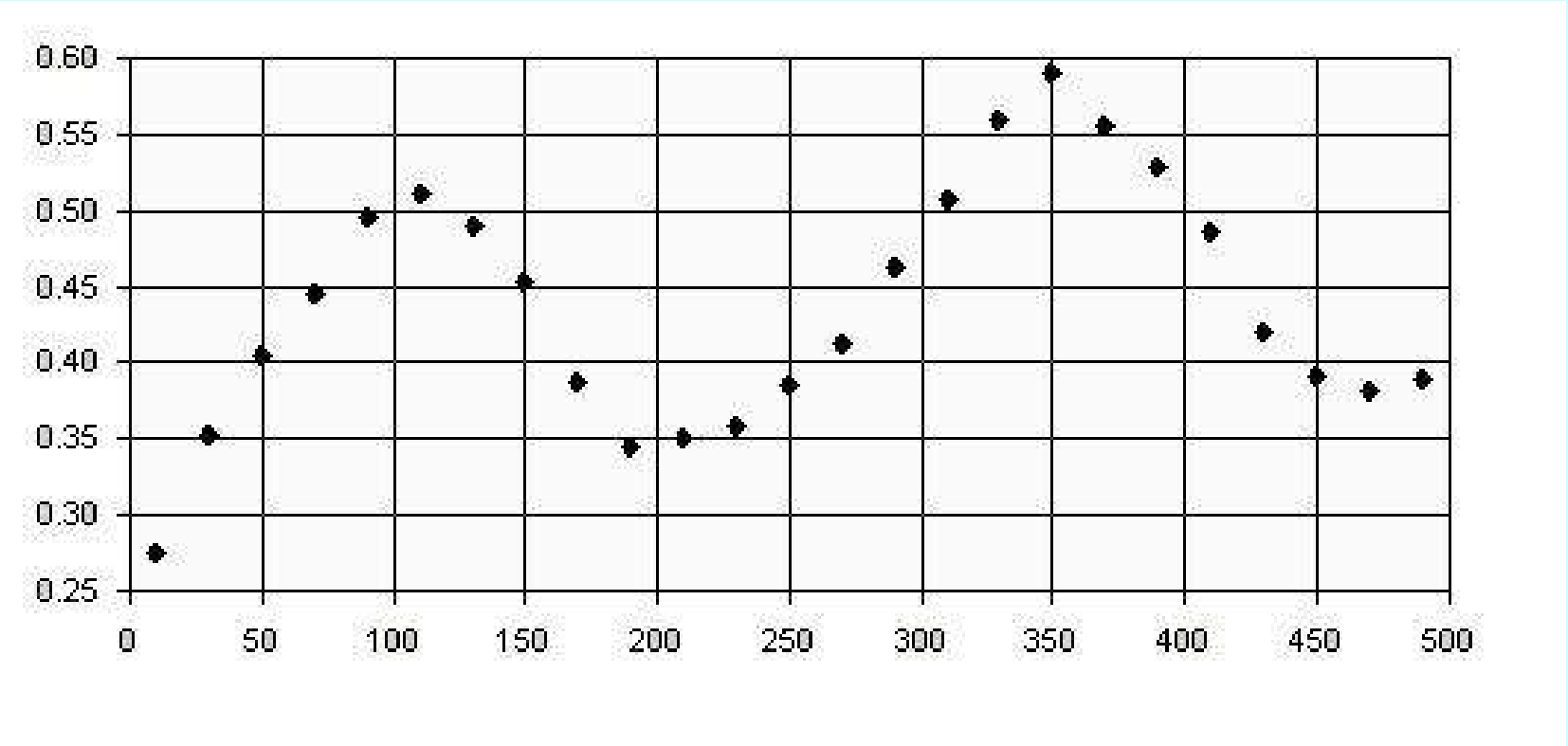
Rotational Variability: AQ Dra, period 5.1 days



Results

Longer Period than Rotation?

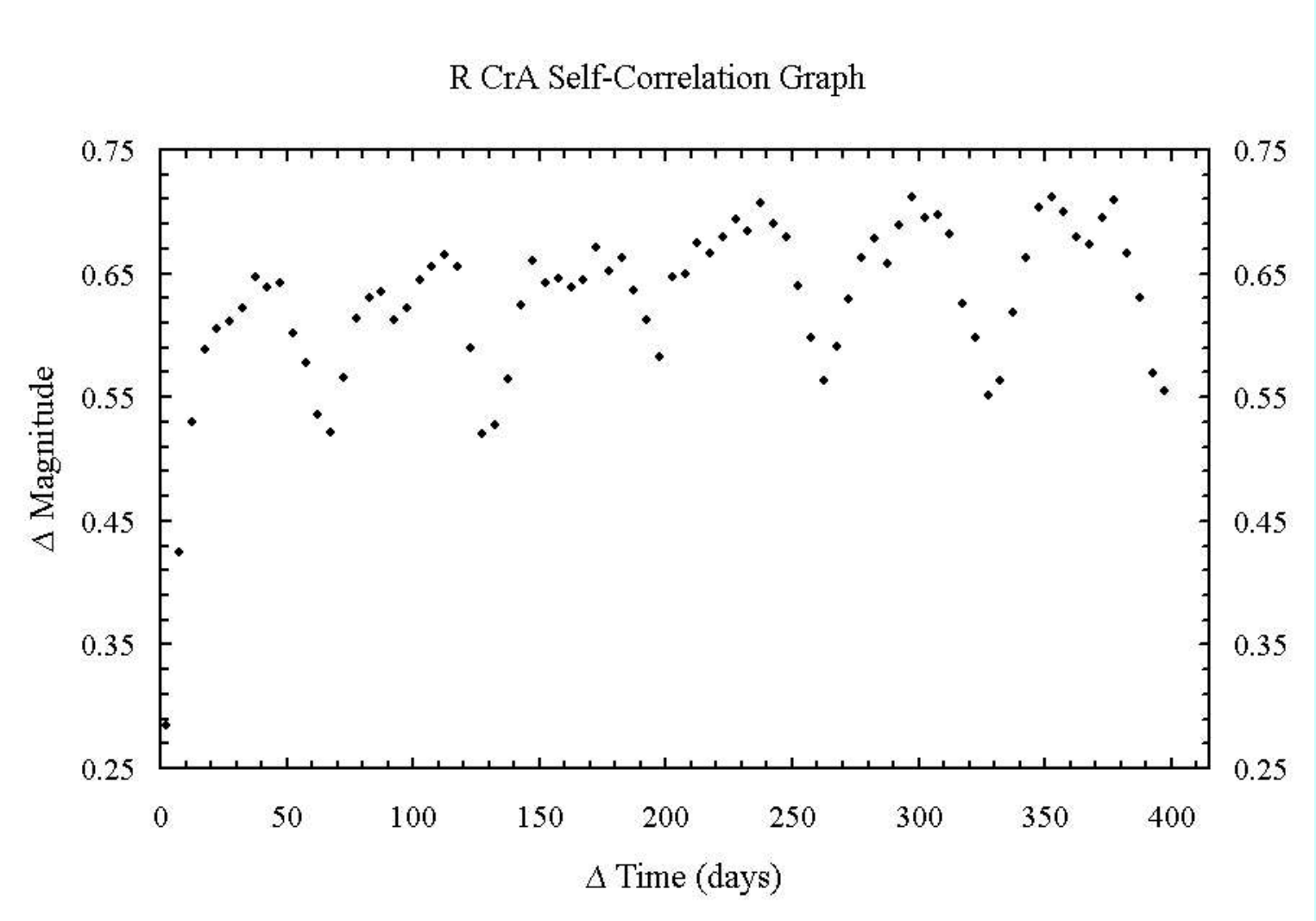
RU Lupi – period 225 days



Results

Longer Period than Rotation?

R CrA Self-Correlation, period 66 days



Results
Non-Periodic: “Profile” of Variability

Self-correlation diagram for T Cha

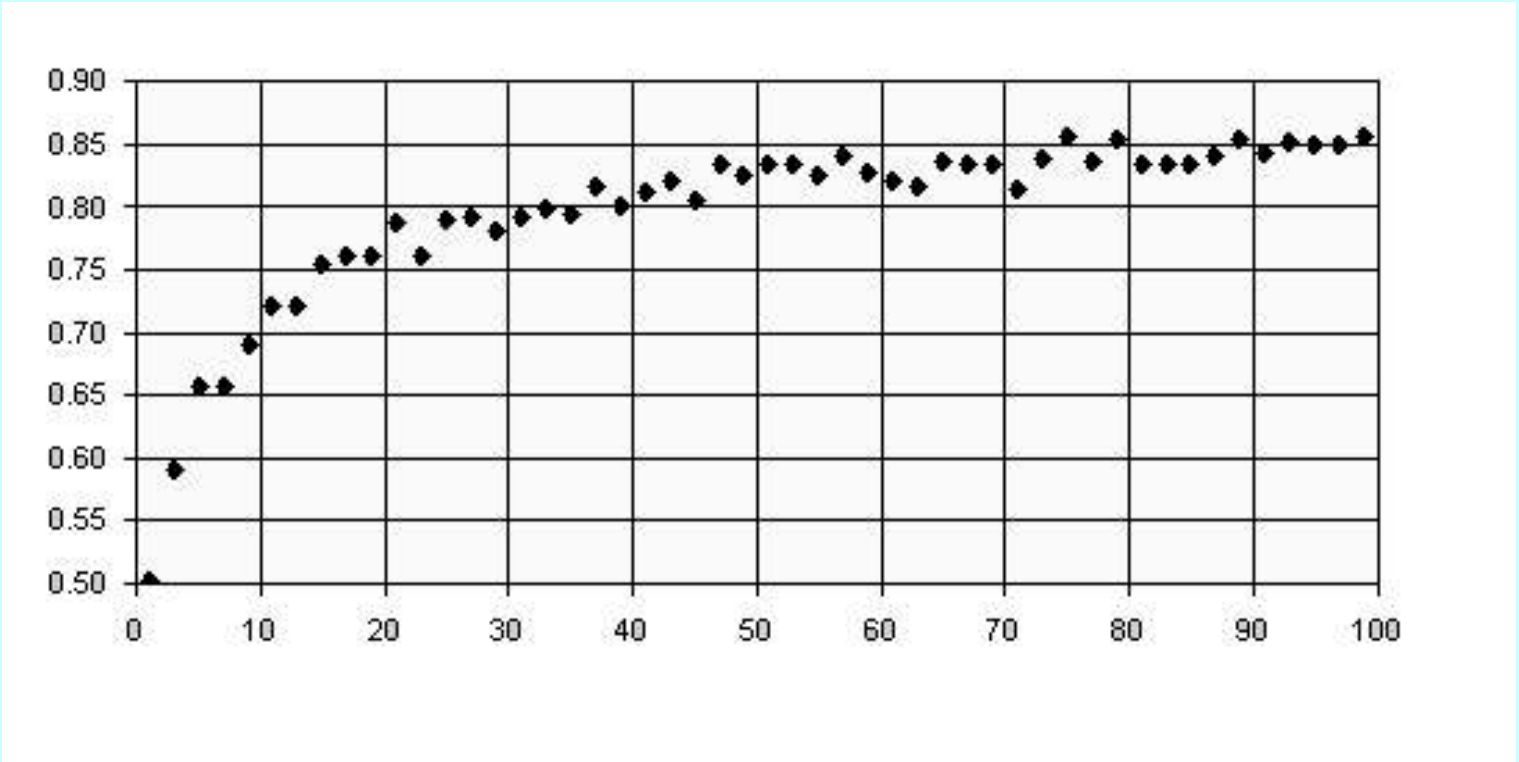


Table 1: Time-series analysis of AAVSO Visual Observations of T Tauri stars.

Star	Sigma	Range	P (d)	Timescales (d)	Comments
SU Aur	0.16	0.25	–	1-800	–
YZ Cep	0.23	0.26	–	1-100	Y
DI Cep	0.21	0.28	–	1-50	–
T Cha	0.25	1.5!	3.3	1-20	M, no Y
T CrA	0.22	0.5:	–	1-1000	M? Y?
AQ Dra	0.3:	0.5	5.5	1-10	no M or Y
RU Lup	0.24	0.4	230	1-100	Y, M
GQ Lup	0.33	0.55	–	1-100	Y
HT Lup	0.08	0.23	6.25	1-100	Y
T Ori	0.34	0.6	–	1-40	–
RY Ori	0.35	0.7	–	1-1000	–
UX Ori	0.30	0.0	200	1-100	no M or Y
BF Ori	0.28	0.7	6	1-30	Y
BN Ori	0.18	0.30	–	1-150	–
V350 Ori	0.21	0.5	–	1-10, 10-100	Y, no M
TU Phe	0.10:	0.25	200	– –	
RZ Psc	0.15	0.20	–	1-2000	no M
NX Pup	0.15	0.38:	–	1-70	Y?
AK Sco	0.16	0.24	–	1-100	Y
V856 Sco	0.15:	0.5	–	1-100	no M or Y
RR Tau	0.27	0.7	–	1-20	Y, no M
RY Tau	0.22	0.5:	–	1-150	Y

Discussion and Conclusions

- Some stars showed spurious one-year and possibly one-month periods, presumably due to the Ceraski effect
- Several stars showed periodic behaviour. The shorter periods (<10 days) are presumably rotation periods; the nature of the longer periods is not clear
- For all stars, the self-correlation diagram shows the "profile" of the variability – the amount of variability on time scales of one to hundreds of days
- **AAVSO visual observations of T Tauri stars have scientific value!**

Acknowledgements and Educational Dimensions

- We thank the AAVSO observers and HQ staff, especially Elizabeth Waagen, for making, validating, and archiving the measurements
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