Ground-based photometric Survey to Search for Pulsational Variability in Ap and Am Stars

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ARIES, Nainital

(D. Nhlpo, N. K. Chakradhari,B. Letarte, O. Trust)

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2nd BINA Workshop, ROB, Brussels

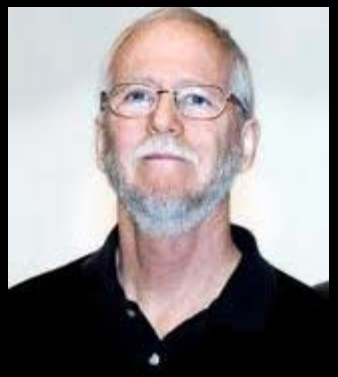
Survey for findind New roAp Stars in Northern Hemisphere

India

Santosh Joshi, Ram Sagar, U. S. Chaubey, S. K. Gupta, ARIES Nainital

V. Girish, S. Seetha, B. N. Ashoka, ISRO, Bangalore

N. K. Chakradhari, Raipur University, Chhatishgadh



South Africa

Thebe Medupe, North West Univesrity, Mafikeng

Peter Martinez UCT, Capetown

Don Wayne Kurtz, UCT/UCLAN, UK

Chemically Peculiar (CP) Stars

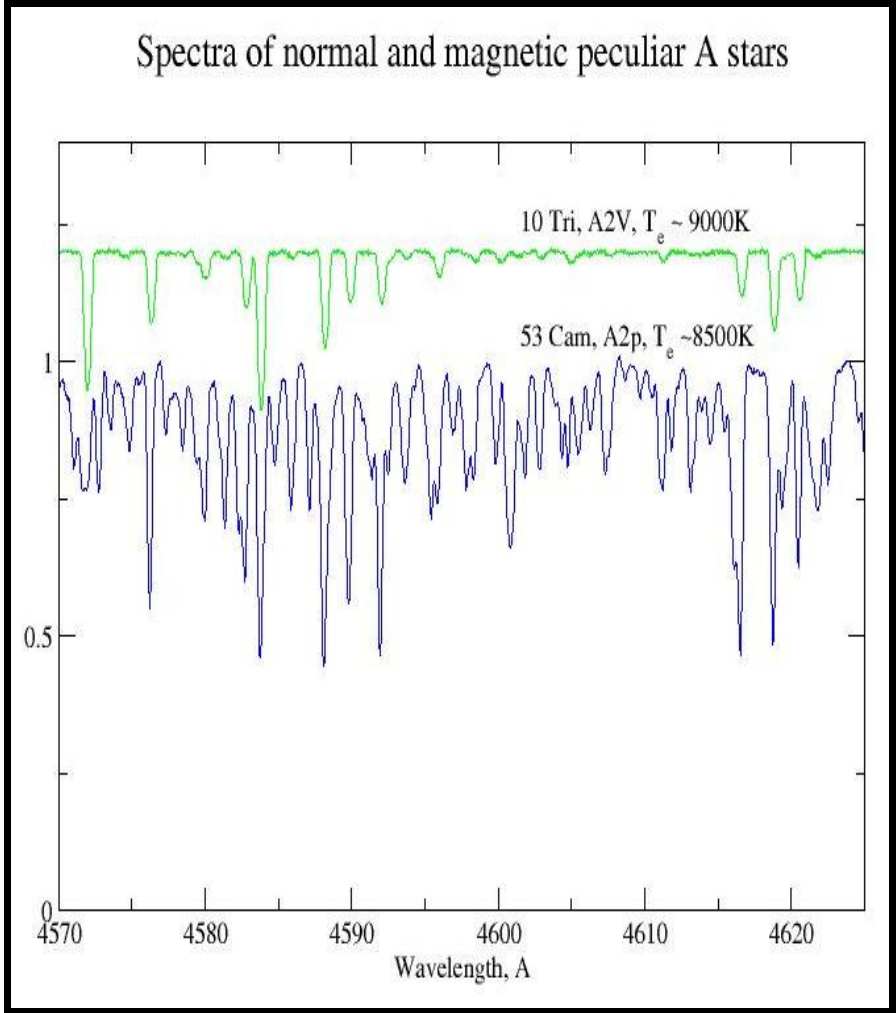
The CP stars are the chemically peculiar stars where atleast one but several elements are significantly overabundant or under-abundant w.r.t. to normal composition of such stars.

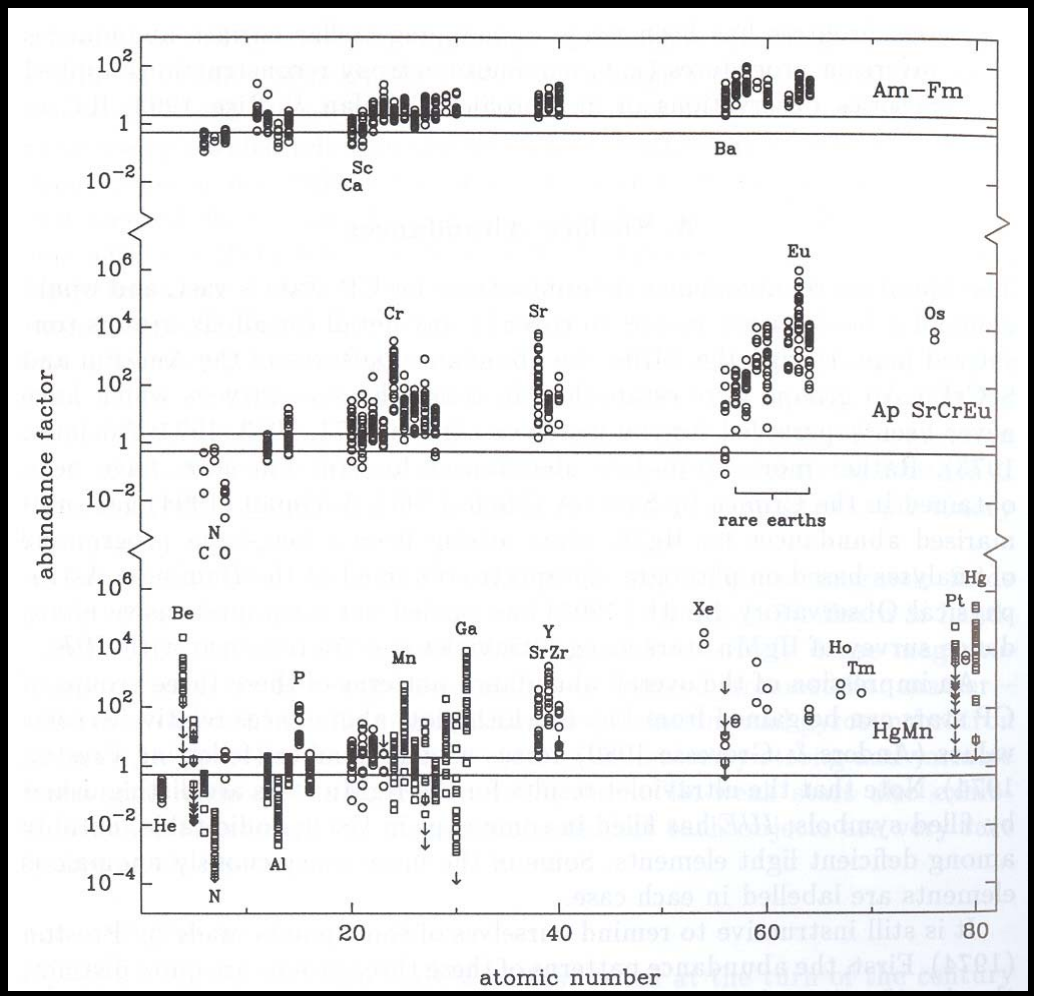
-> Optical Spectrum shows abnormal strength (strong/weak)

The peculiarity in CP stars is due to microscopic diffusion arises from the competition between radiative pressure and gravitational settling.

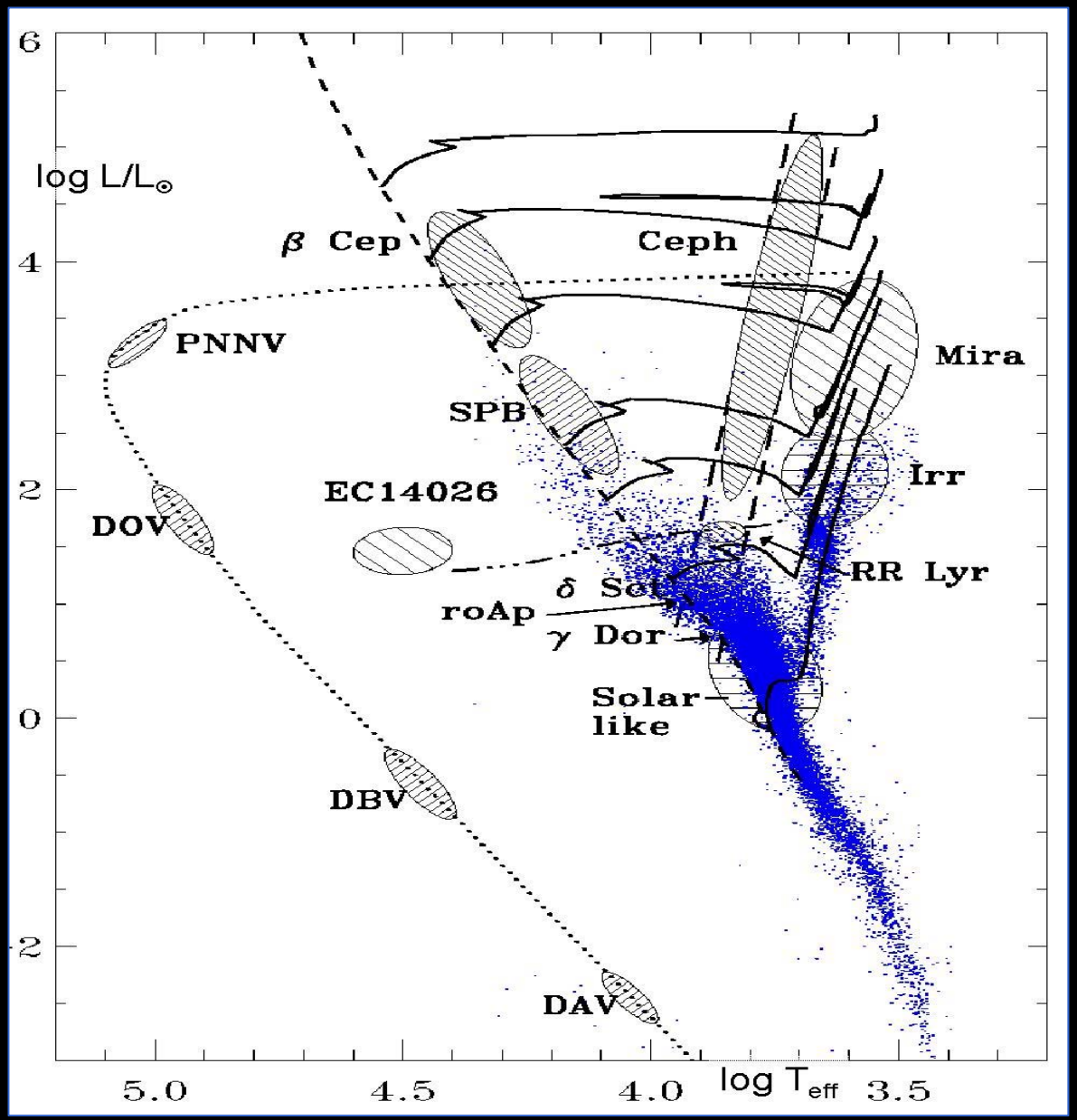
Classical Name	Preston Group	Characteristic	Magnetic	Temp (K) Range
Am-Fm	CP1	Weak Ca II, Sc II, enhanced metals	Yes/No	7000-10,000
Bp-Ap	CP2	Enhanced Sr, Cr, Eu, Si	Yes	7000-16,000

Comparison with the Solar Abundance





Asteroseismology for Pulsating A-F type CP Stars



Photometric Search for Pulsation in Ap and Am Stars

1. Kurtz (1982-1989)	5 Ap SrCrEu field stars
2. Matthews & Wehlau (1985)	4 Northern field Ap stars
3. Matthews et al. (1988)	4 Ap stars in NGC 2516
4. Hellar & Kramer (1988)	4 Northern field Ap stars
5. Schutt (1991)	36 normal A0-A5 stars
6. Nelson & Kreidl (1985-1991)	120 Northern Ap stars
7. Belmonte (1989)	8 Northern Fp/Ap stars
8. Hildebrandt (1992)	4 Normal and peculiar A stars
9. Cape Survey (1991-1994)	134 Southern Ap SrCrEu stars
10. Dorokhova et al. (1998)	Unspecified northern Ap stars
11. Handler et al. (1999)	17 Northern Ap stars
12. Nainital-Cape Survey (1999-)	330 CP stars

Search for New Rapidly oscillating Ap (roAp) Stars in Norhthern Hemisphere

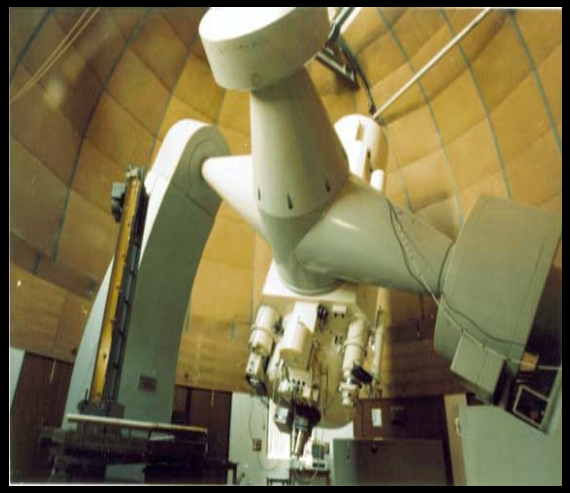
- Pulsating(*non radial*) variable star of spectral type late A to early F.
- Cool(7500K-8500K), magnetic(kG).
- Periods (may be multi-periodic) range from ~ 5 to 23 minutes.
- Amplitude variation is found in mill magnitude range (16mmag ~ peak-peak).
- Pulsate in high overtone (n > 30-40), low degree (l <3), non-radial p modes.

Photometric Observations

Ground Based Photometry : 104-cm at ARIES
: 50-cm at Sutherland
: 130-cm at Devasthal
(DST-NRF funded Indo-South African Projects)

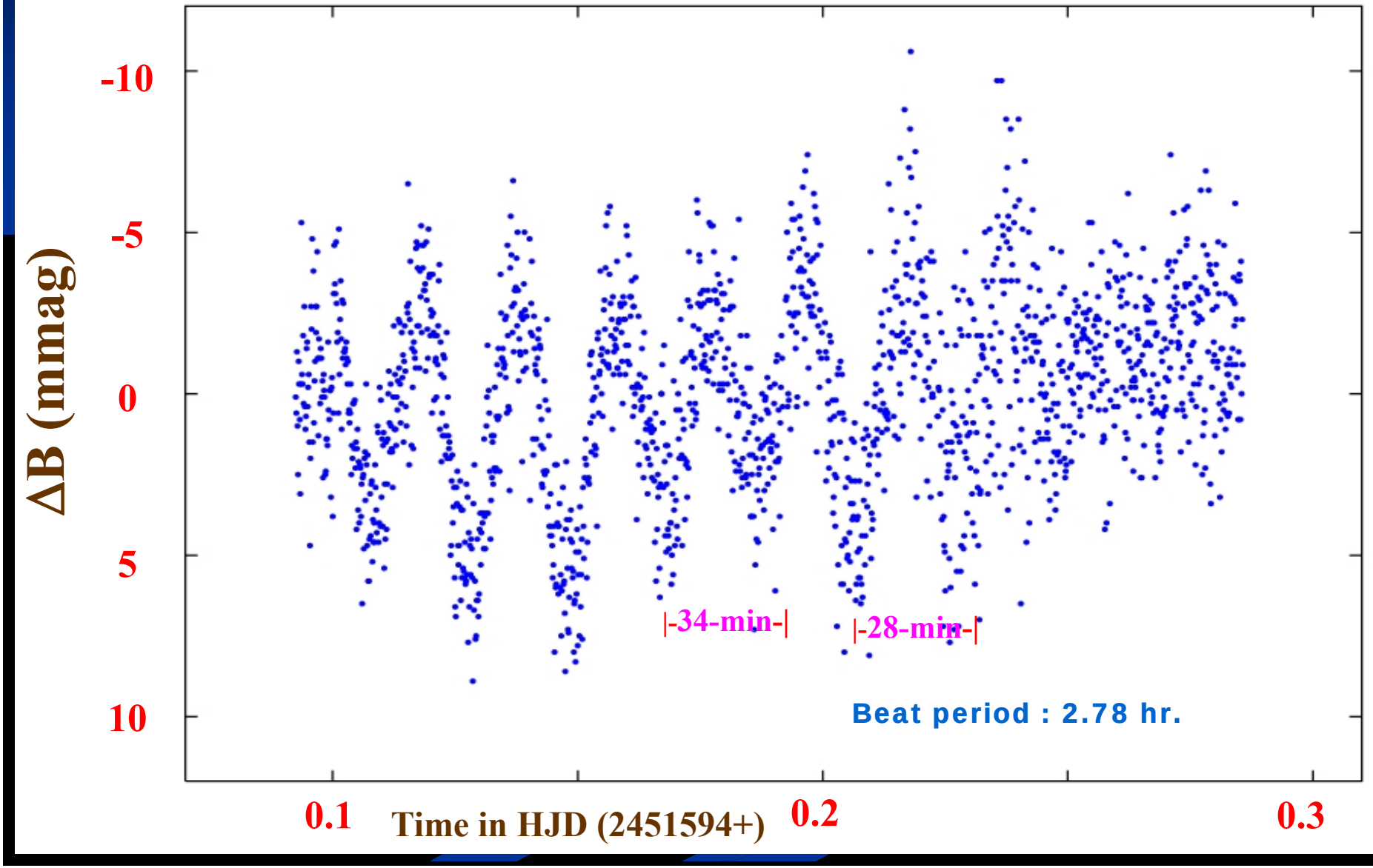
Instruments : PMT based Photometers and CCDs

Exp. time : 10-s, Filter : B, T : 1 to 2 hr.

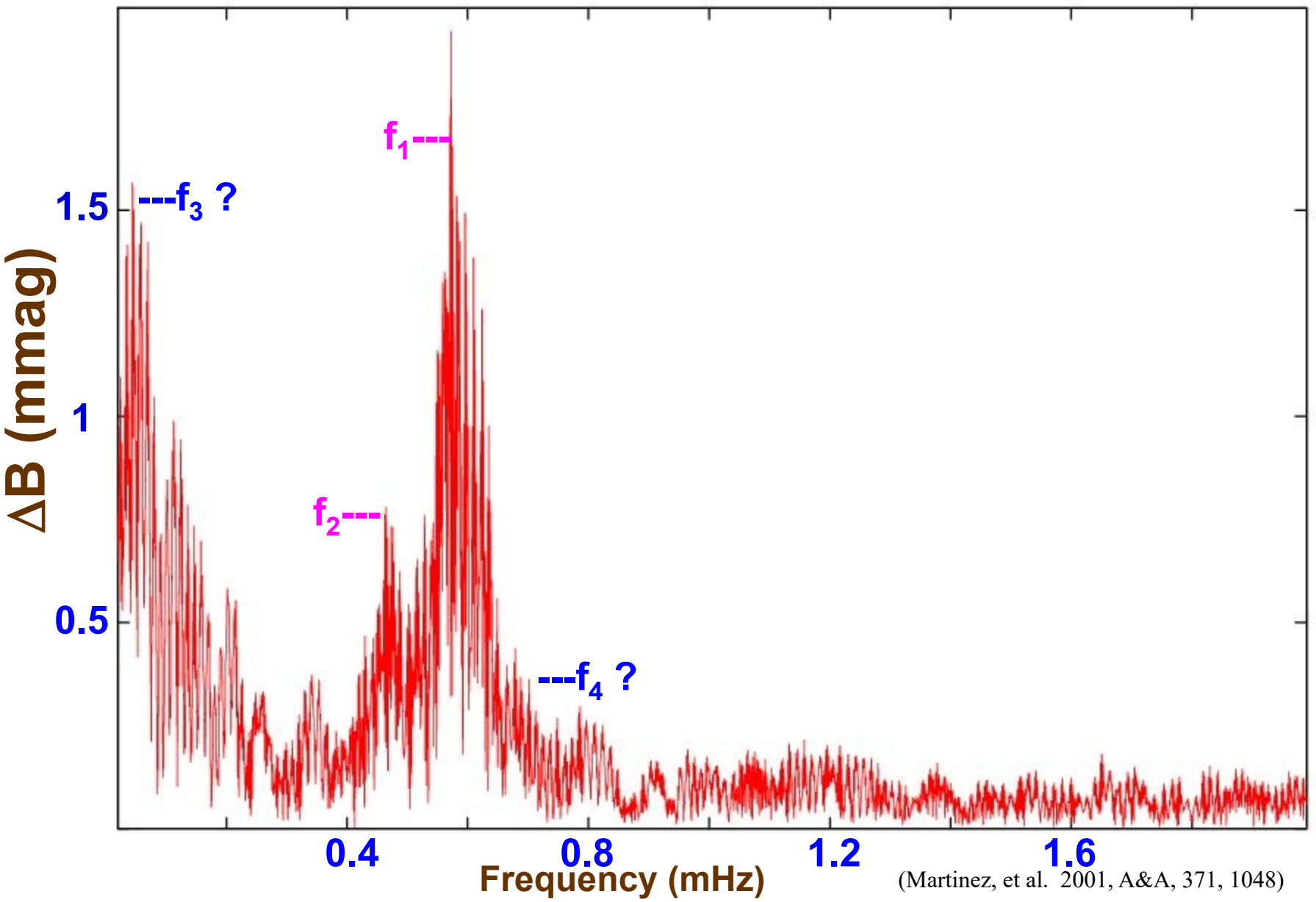


- **Data Reduction : Light Curves (sky subtraction and correction for extinction), FT**

Discovery of Pulsation in Am Star HD 13038

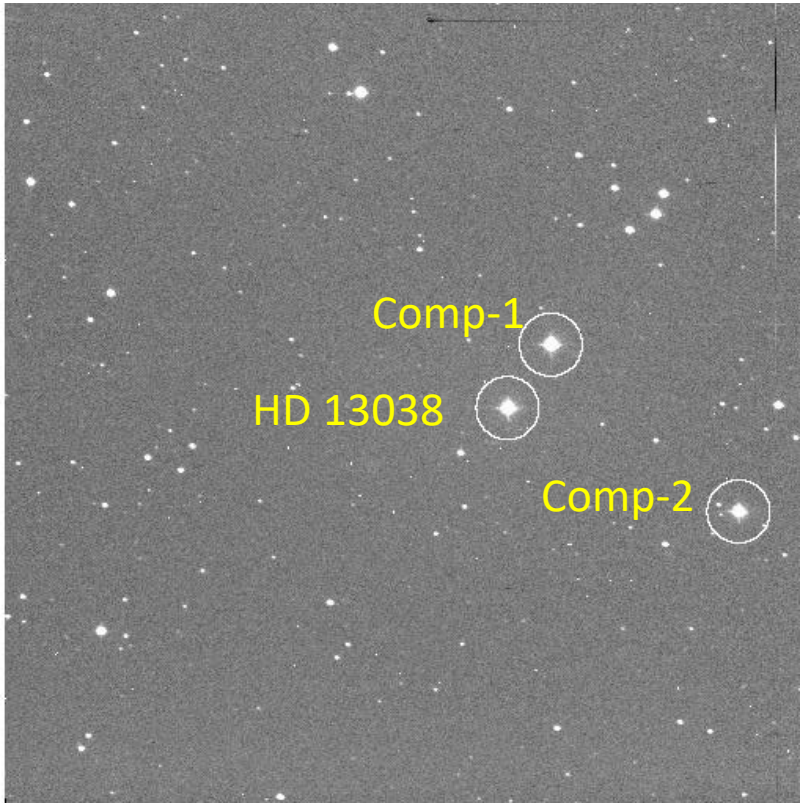


Amplitude Spectrum of Star HD 13038



(Martinez, et al. 2001, A&A, 371, 1048)

Ground Based CCD Time-series Observations of HD 13038



Observation Details

Date of observation : 2006-10-06

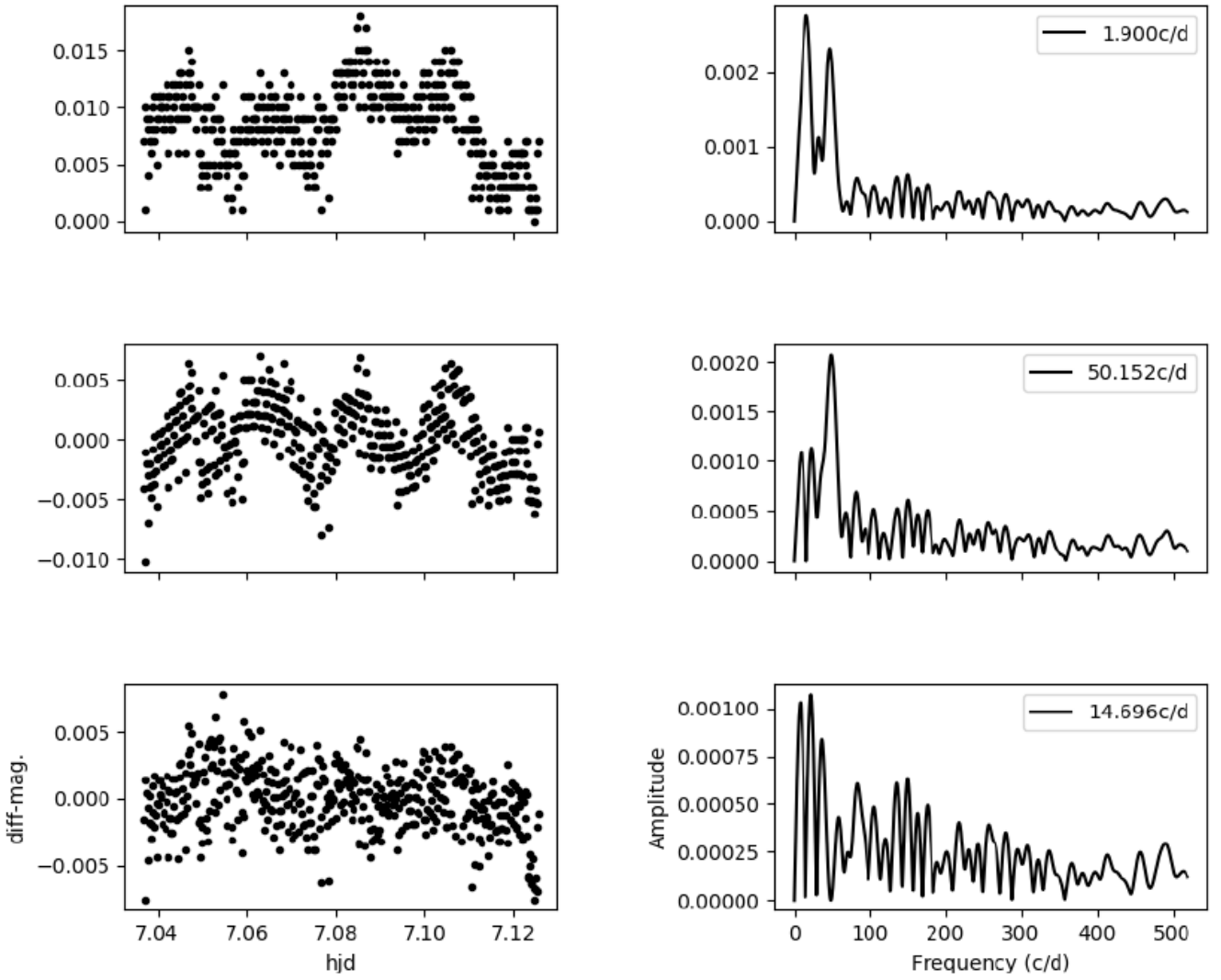
Telescope : 104-cm Sampurnanand Telescope

Detector : SITe 2k X 2k pixels

Integration : 5-s each frame

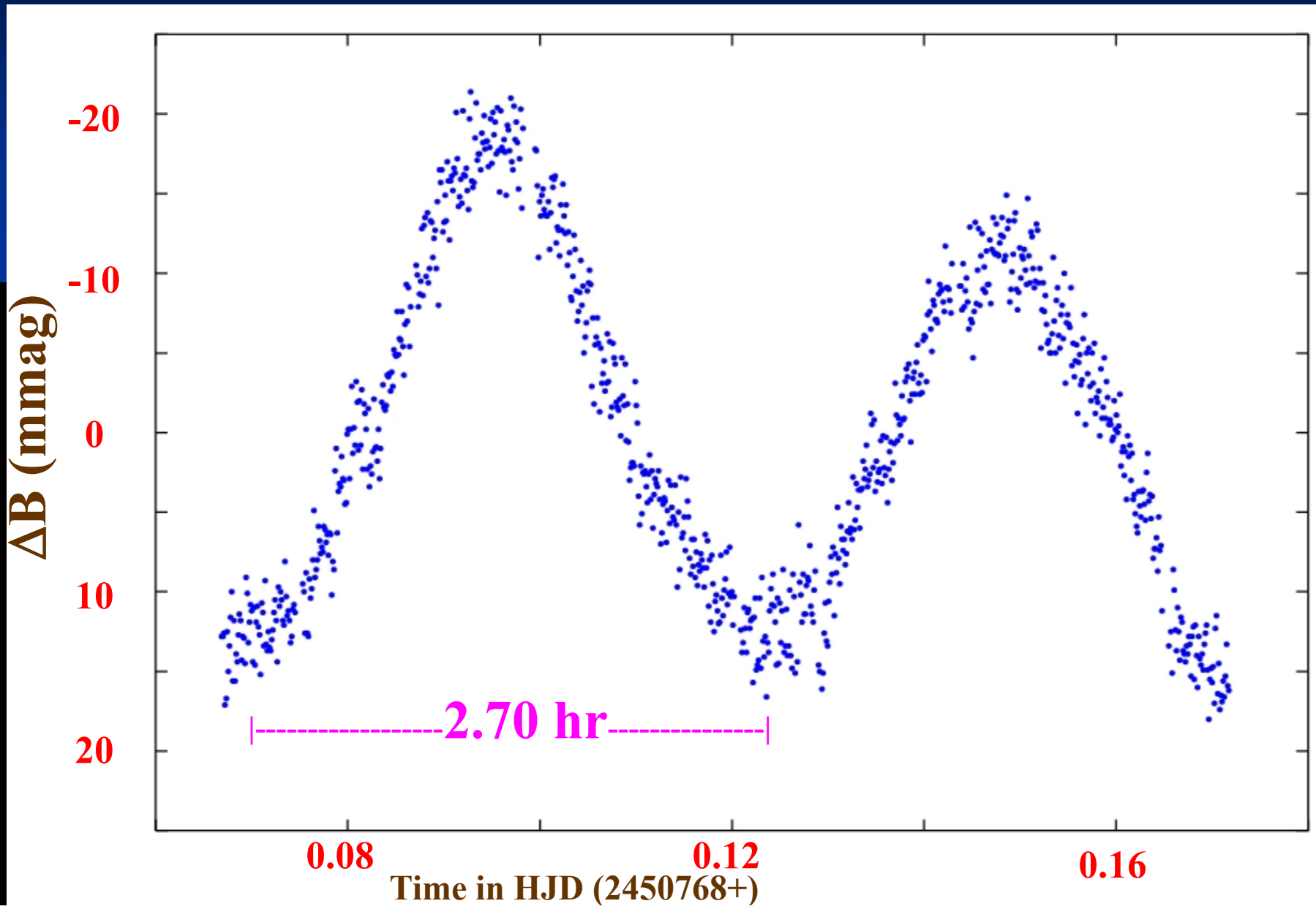
Filter : B

Total Duration : 6.5 hrs

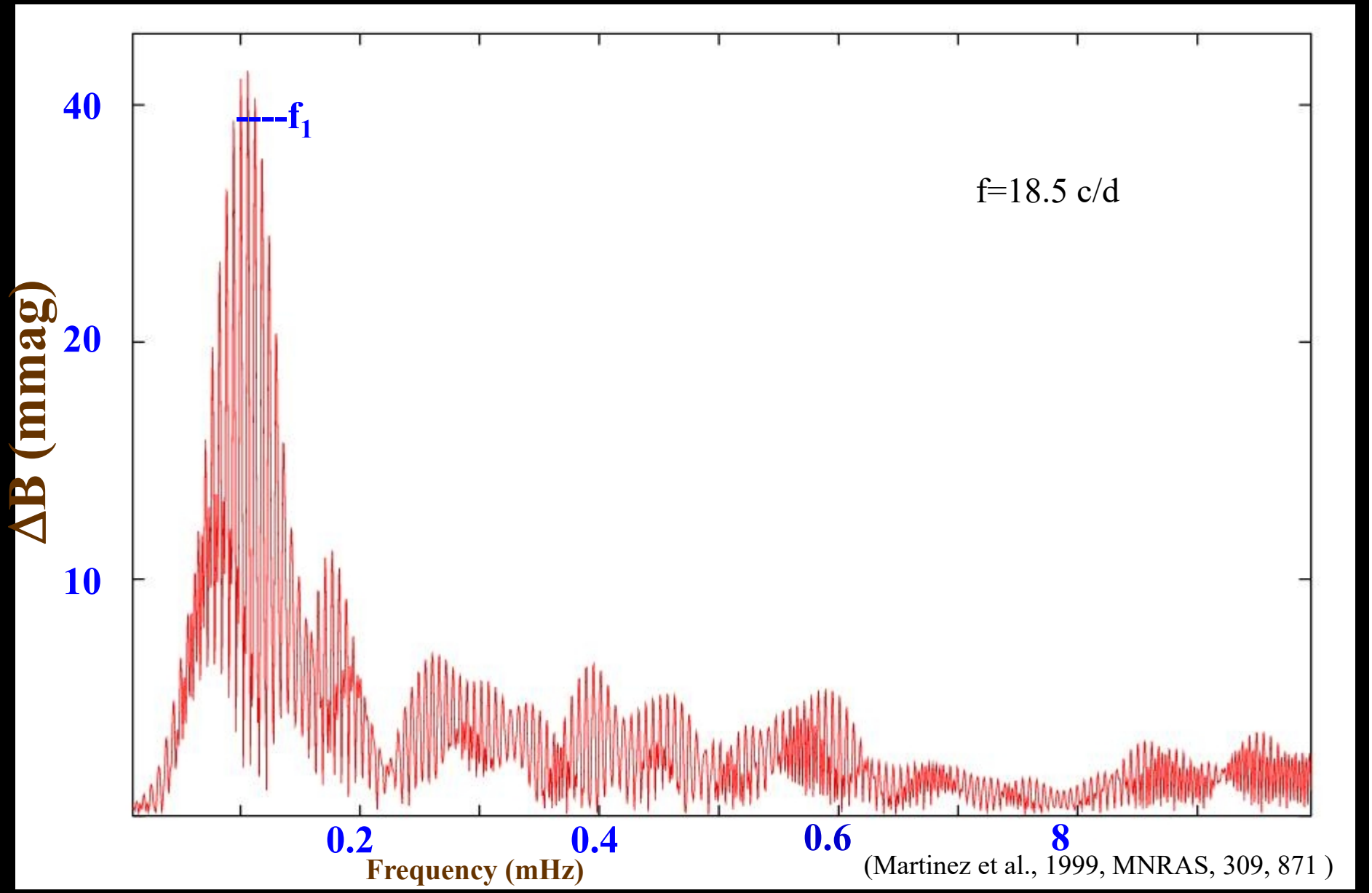


f(c/d)	Amp.	phase
1.9000893	0.0372038746	0.809662957895398
50.151928	0.0022336910	0.913319361264868
14.696417	0.0025368293	0.936665450935472

Discovery of Pulsation in an Am Star HD 13079

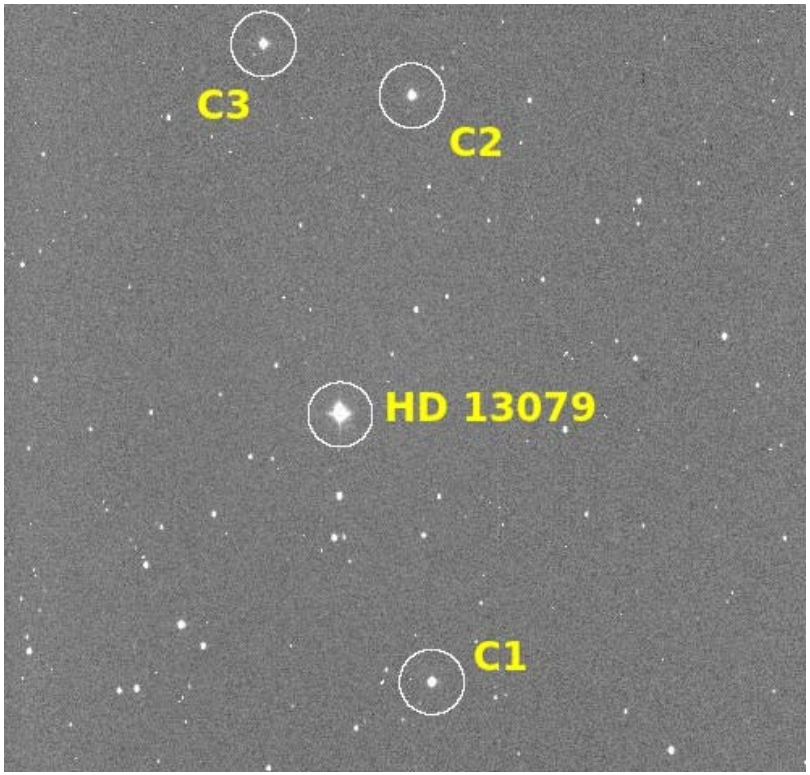


Frequency Analysis



(Martinez et al., 1999, MNRAS, 309, 871)

Ground Based Time-Series Monitoring of HD 13079



Observation Details

Date of observation : 04 and 07 October 2006

Telescope : 104-cm Sampurnanand Telescope

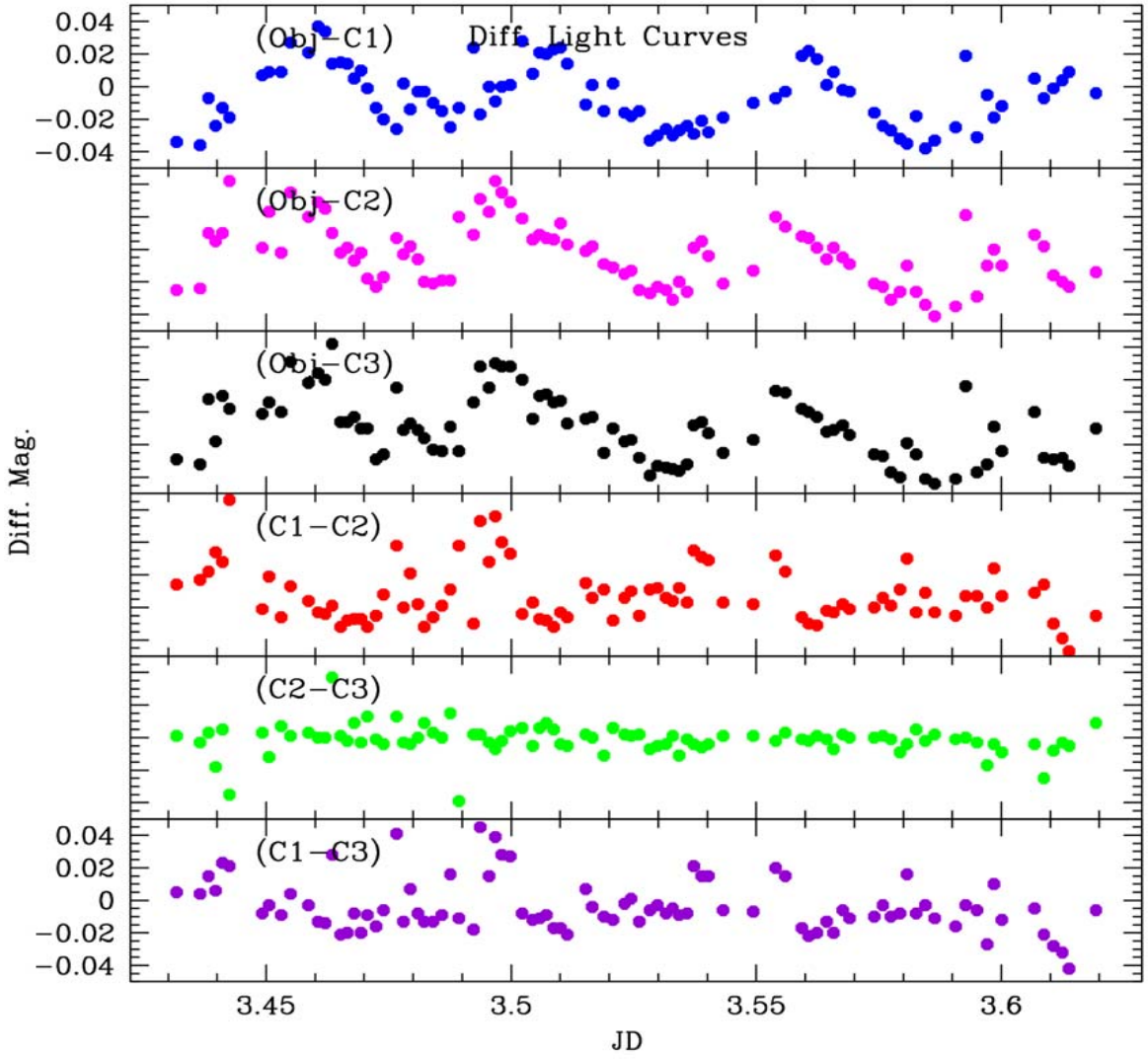
Detector : SITe 2k X 2k pixels

Filter : B

Integration : 10-s each frame

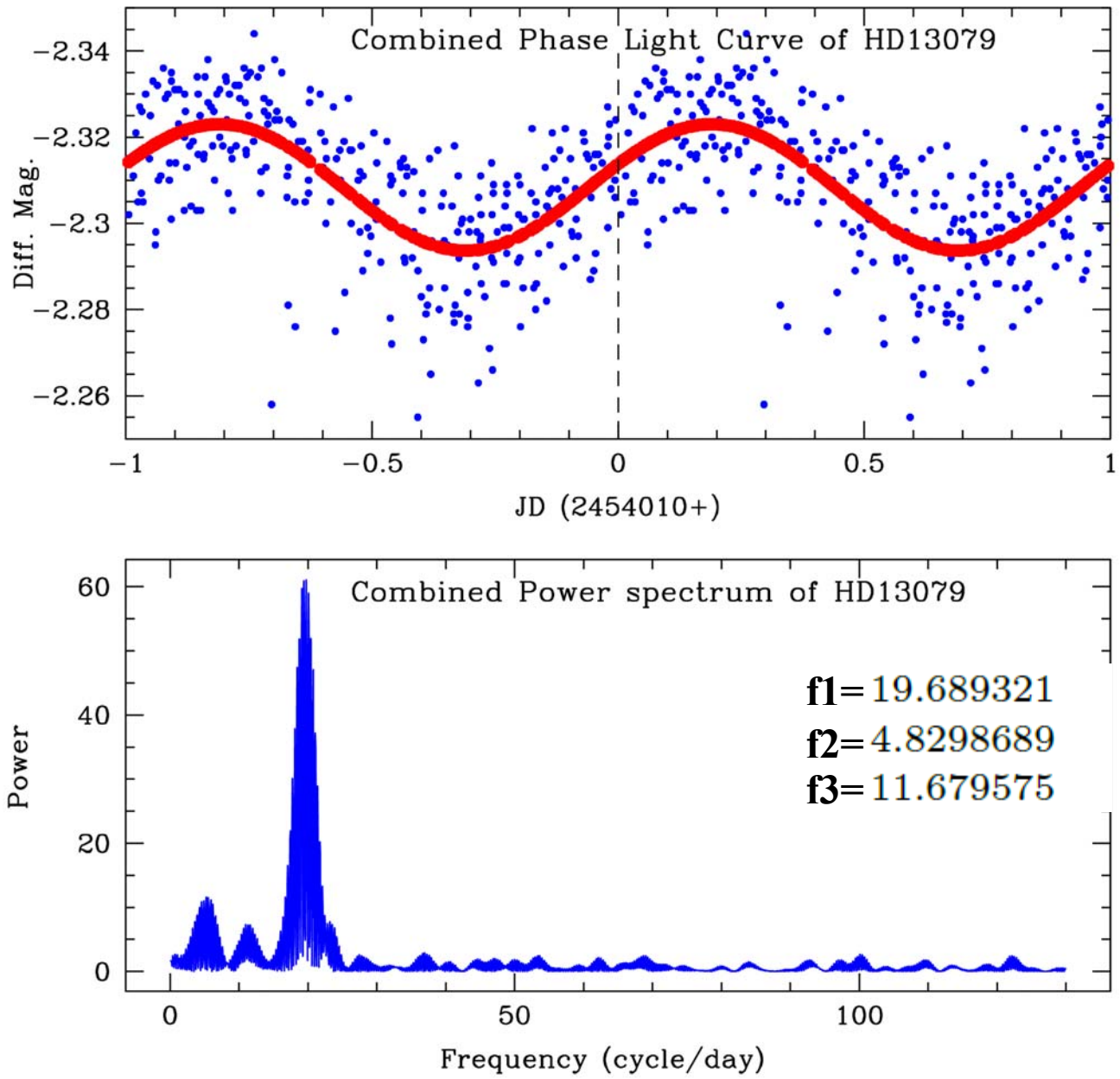
Total Duration : 4.5 hrs on 2006-10-04
: 8.2 hrs on 2006-10-07

Sample Light Curves 2006-10-04



Note : For better viewing, the light curves are shifted vertically to bring the mean at 0 mag.

Frequency Analysis



Super-wasp Observations of HD13079

Martinez at al. (1999)

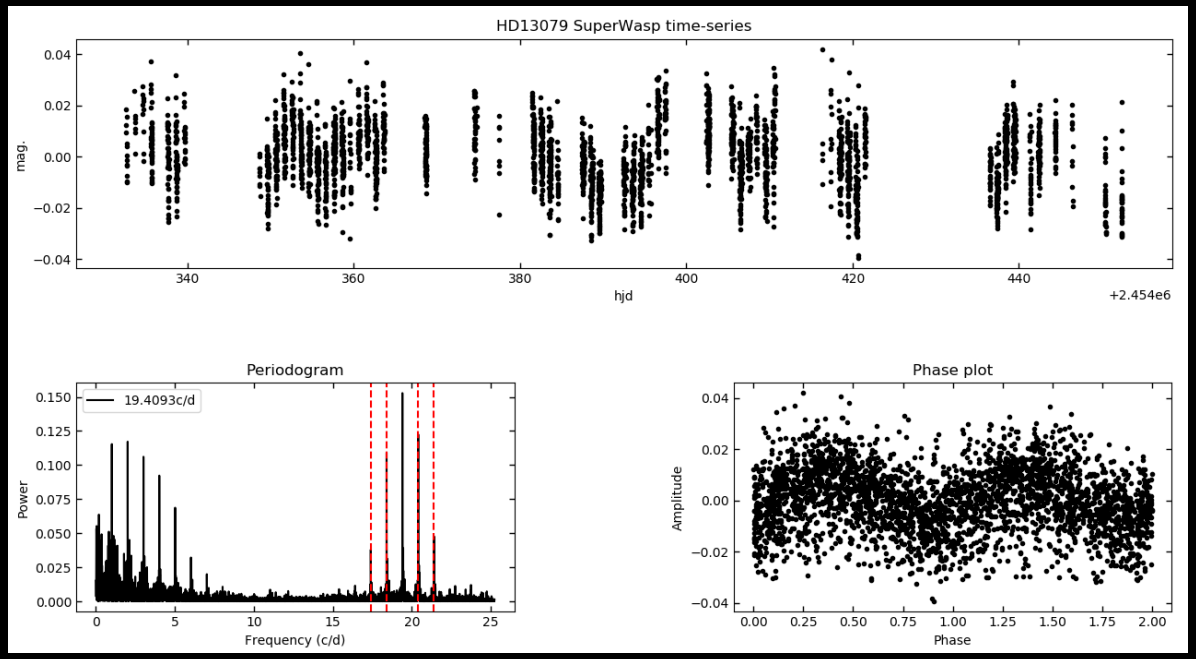
f=18.5 c/d

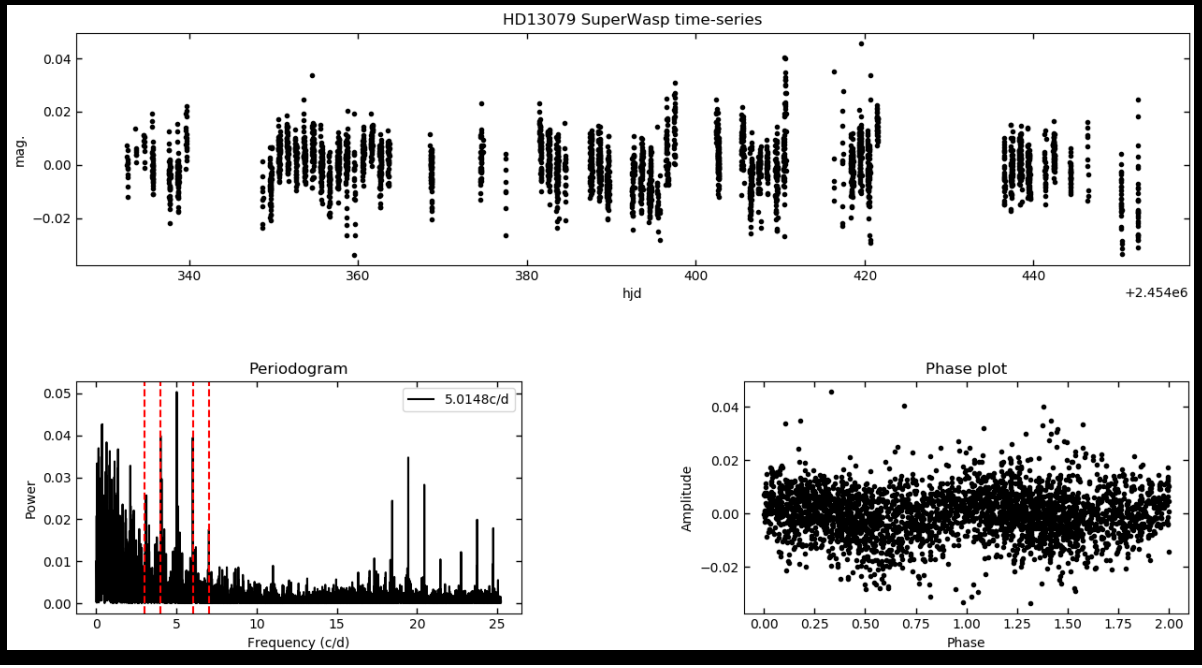
Smalley at al. (2011)

f1=19.41 c/d
f2=19.46
f3=24.76 ? ? ? ? ? ? ?
f4=17.59
F5=19.33

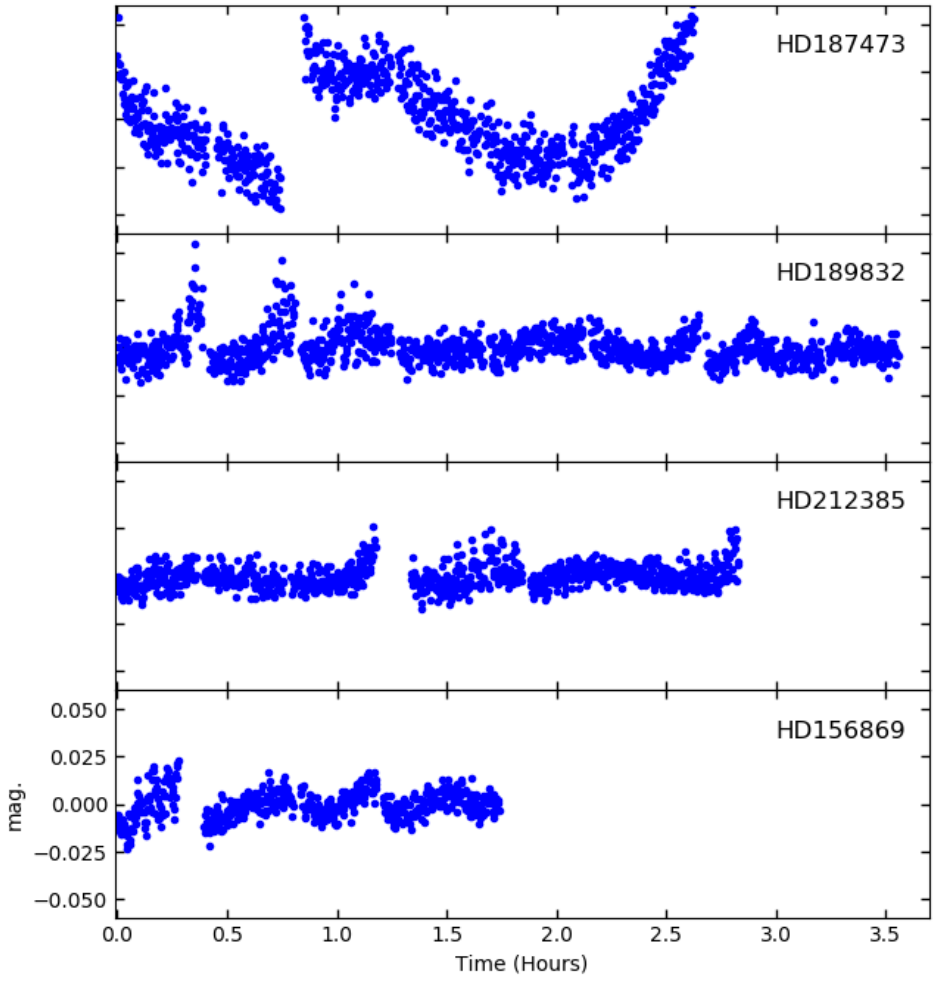
Present Work

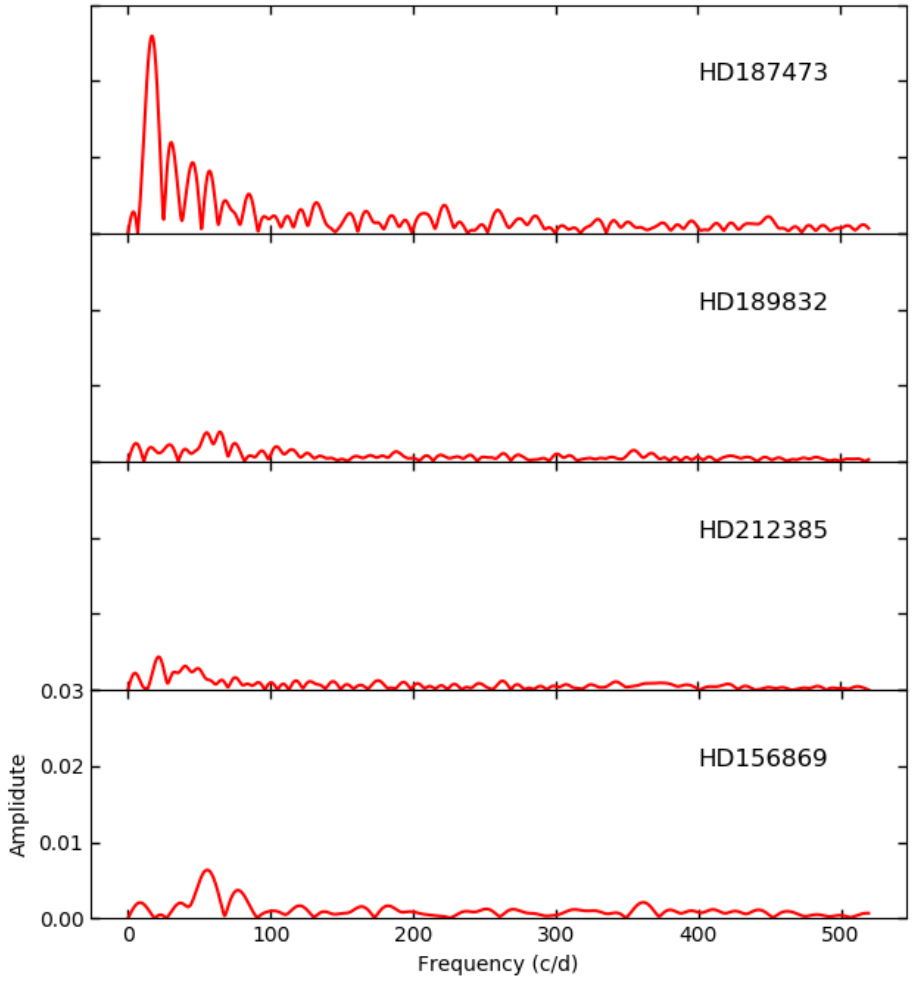
f1=4.82 c/d
f2=19.68
f3=11.67
f4=16.32





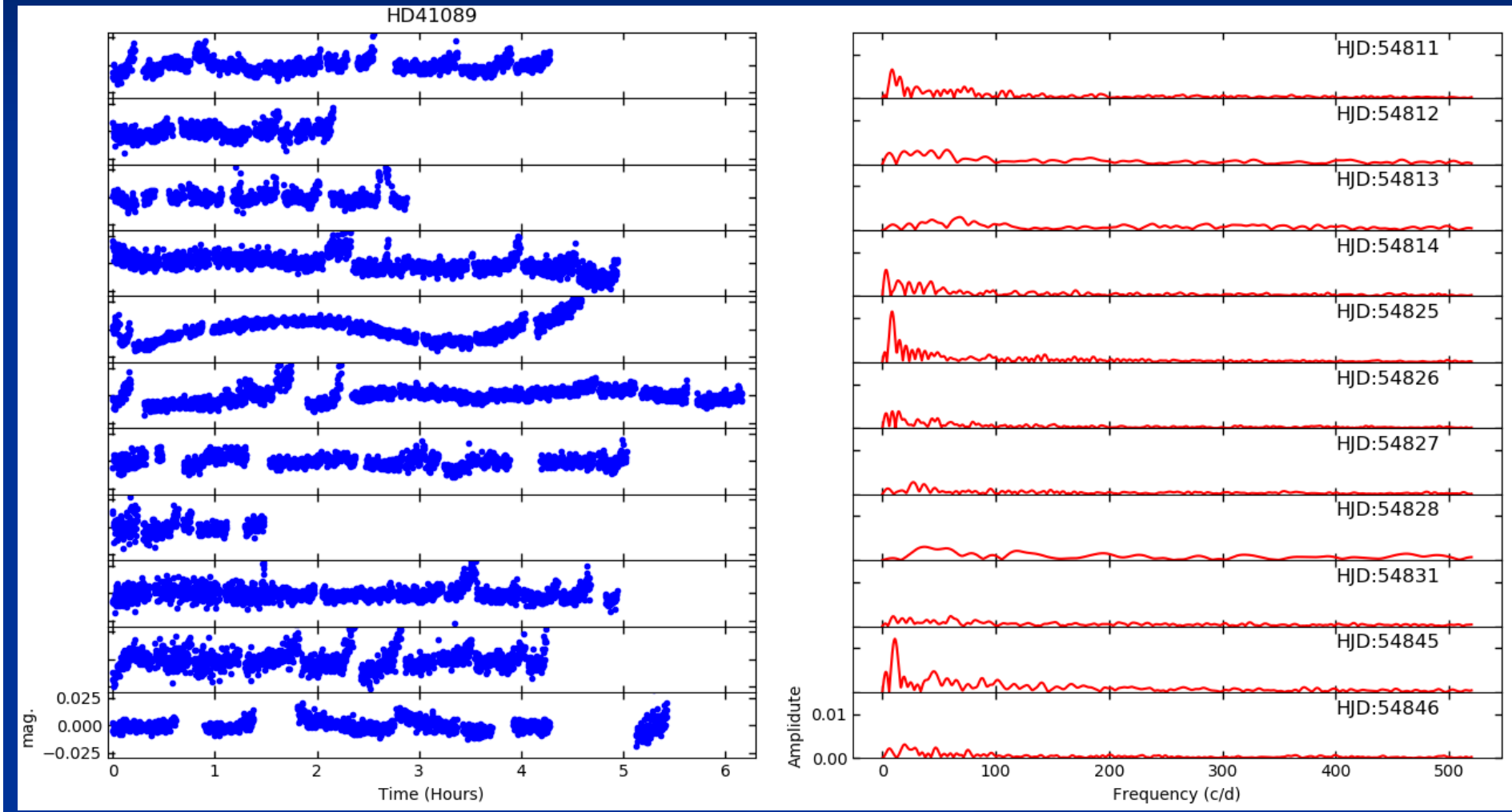
Sample Null Results : Light curves and FTs



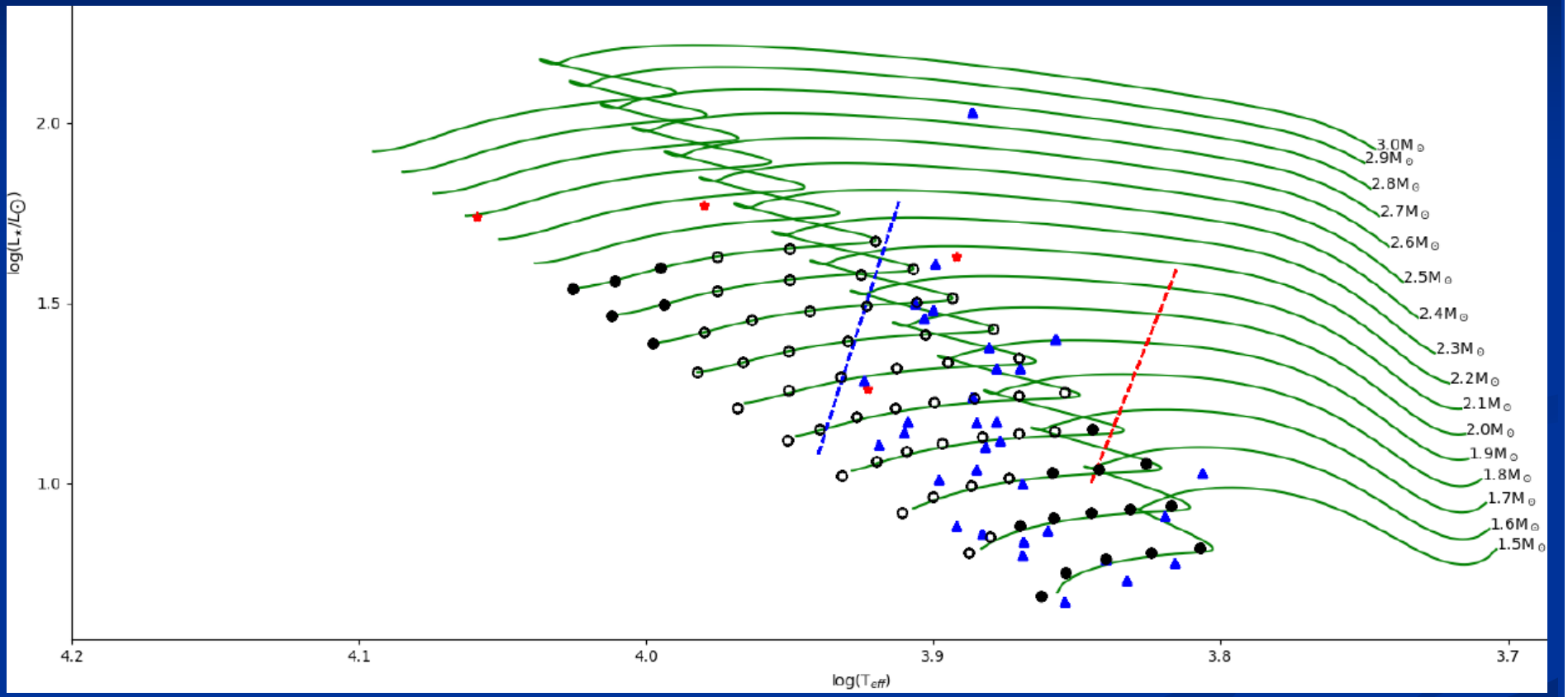


star HD	α_{2000}	δ_{2000}	M_v mag	Sp.type (SrEuCr)	π mas	b-y mag	m_1 mag	c_1 mag	β mag	log(T_{eff}) K	log[$\frac{L_*}{L_\odot}$]
41089	06 00 51	-42 52 14	6.57	B9IIIp	4.25	-	-	-	-	4.179	2.49
212385	22 24 38	-39 07 37	6.84	A2p	7.92	0.067	0.225	0.946	-	3.923	1.26
187473	19 51 10	-27 28 19	7.32	Ap	5.95	-0.022	0.157	0.677	-	4.059	1.74
156869	17 22 52	-52 58 41	7.92	Ap	3.59	0.041	0.165	0.990	-	3.980	1.77
189832	20 03 35	-38 51 09	6.90	A6p	5.86	0.139	0.199	0.949	2.822	3.892	1.63

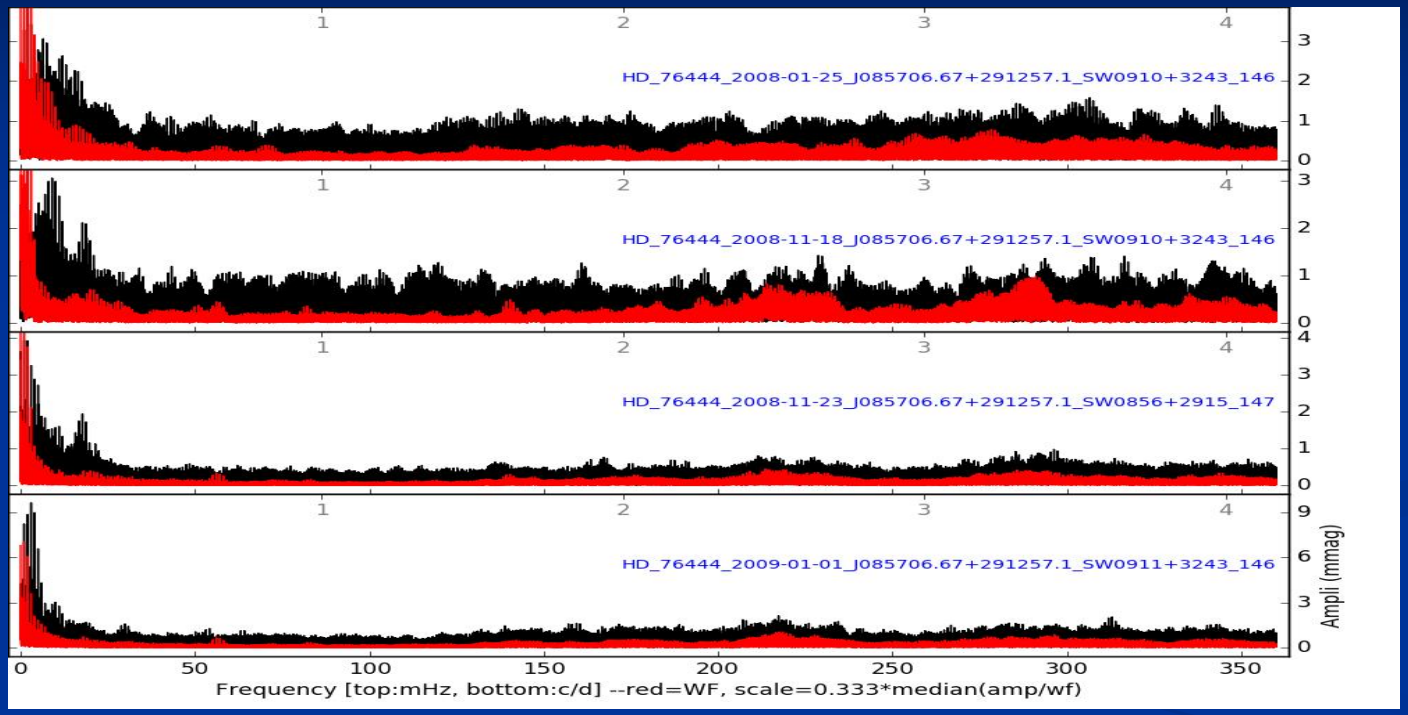
Intense Monitoring of HD41089

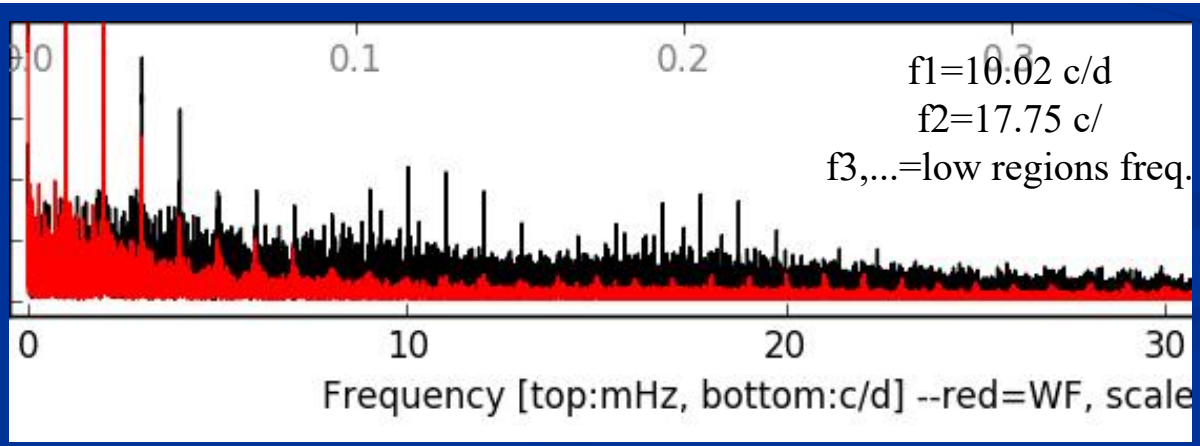


H-R Diagram of the Null Results

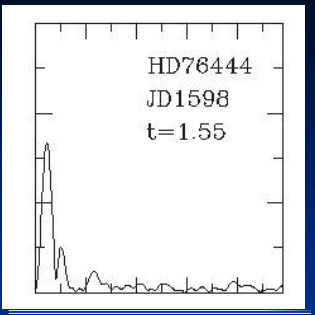


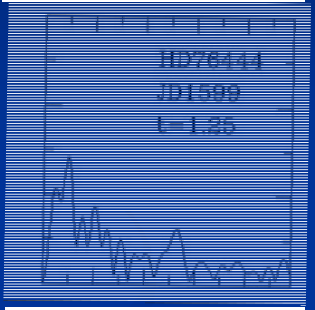
Super-wasp Analysis of the Samples Observed under Nainital-Cape Survey Project

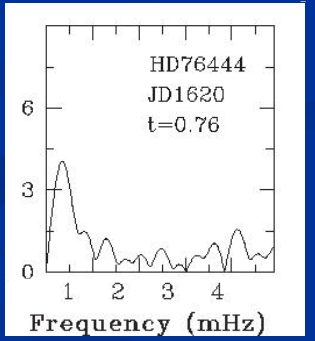




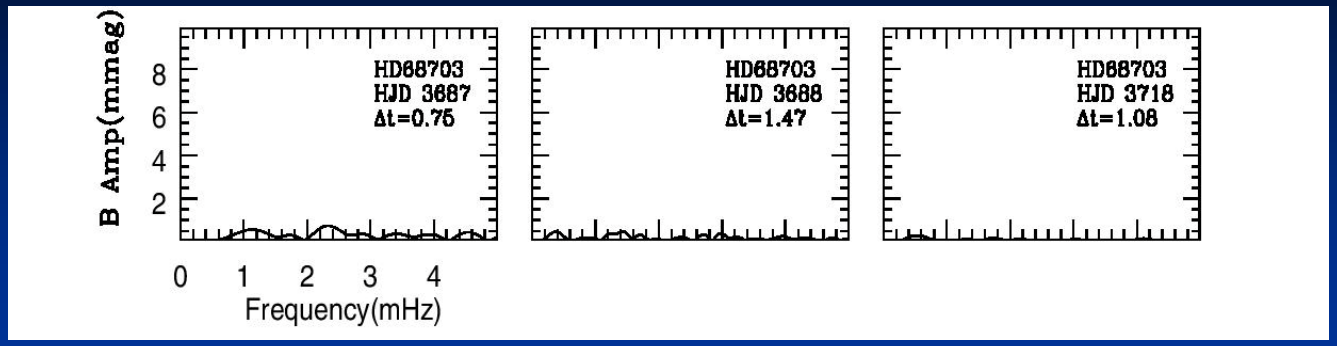
f1=10.02 c/d
f2=17.75 c/
f3,...=low regions freq.

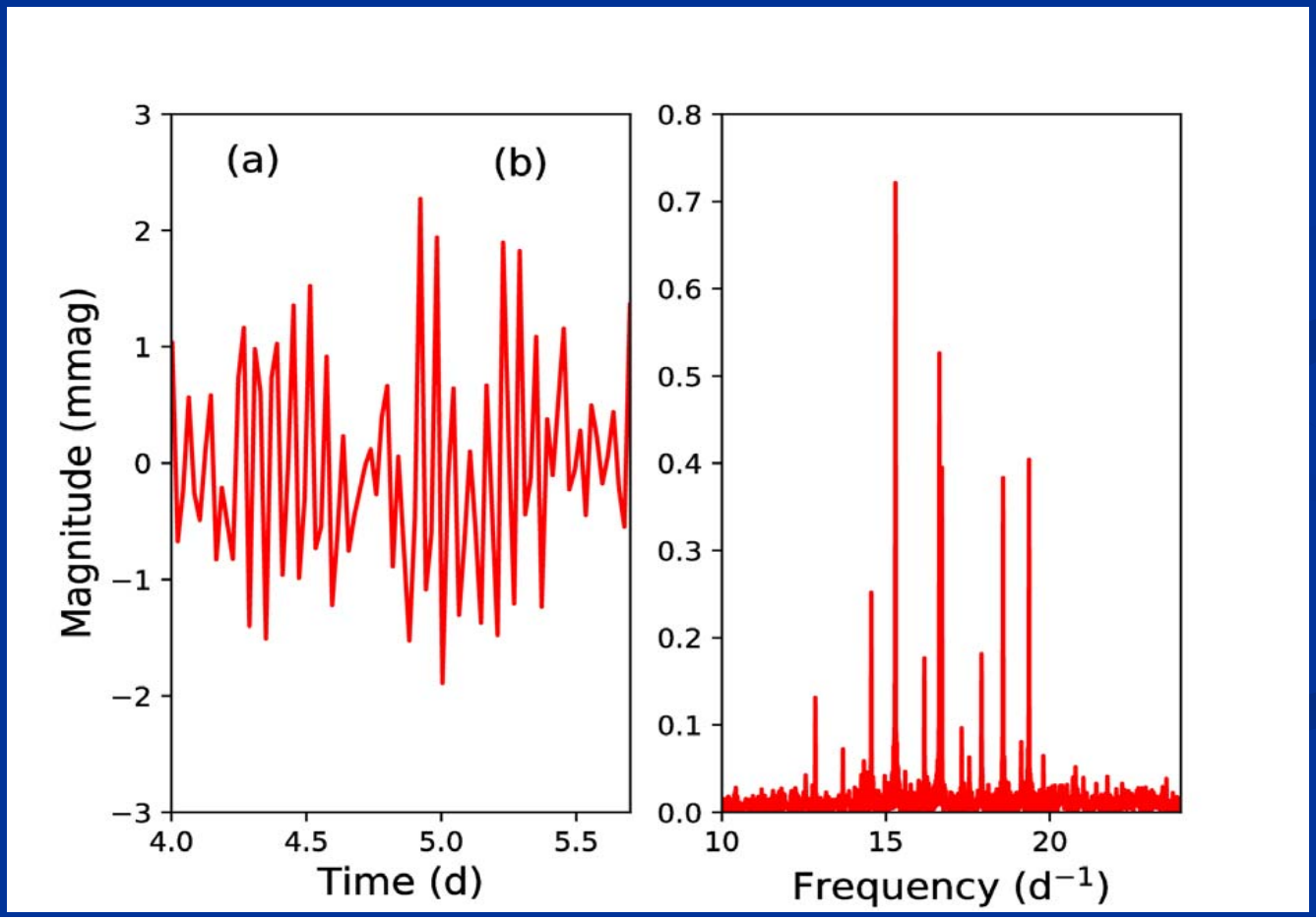






Ground and Space Kepler K2 Analysis of HD68703





Possible Collaborations

- **Continue the Nainital-Cape Survey Project**
- **Asteroseismology of the Kepler Pulsating Variables**
- **Search for Variables in Open Star Clusters**
- **High-resolution spectroscopy of Pulsating Stars using DOT.**
- **Any Many !**

Conclusion and Future Perspectives

> Preliminary data analysis showed some signature of variability in HD41089. However, the follow-up observation could not confirm any variability, resulting in a null result.

> Four candidates shown under RESULTS did not show any light variation in the initial observations and were not monitor further ,thus classified as null-results as well.

Research Projects Funded by DST, Govt. of India

- **Indo-South African Projects (DST-NRF: 2001-2016)**

1. Nainital-Cape Survey for roAp Stars **(PI : U. S. Chaubey**; 2001-2004).
2. Search and study of variability in Ap and Am Stars **(PI : S.Joshi;** 2008-2013).

Total Reserach Papers Published : 38

- **Indo-Russian Projects (DST-RFBR:2008-2018)**

3. Studies of CP and RoAp Stars**(PI : S. Joshi;** 2008-2012).
4. Time-resolved Photometric and Spectroscopic study of the CP Stars (**PI : S. Joshi**; 2013-2016).

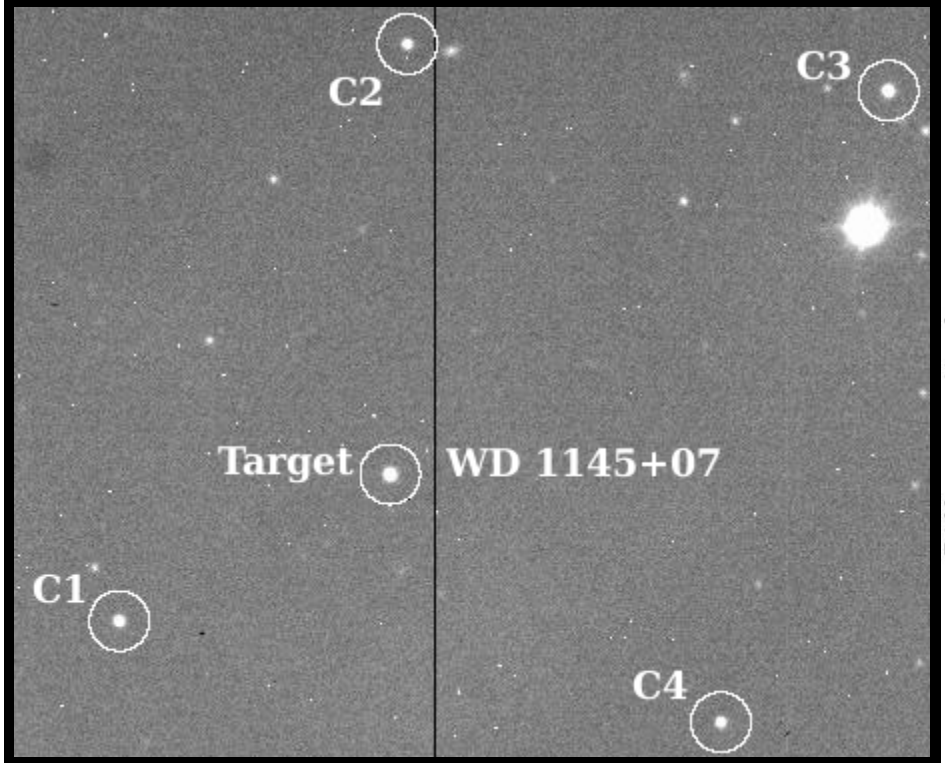
Total Reserach Papers Published : 6

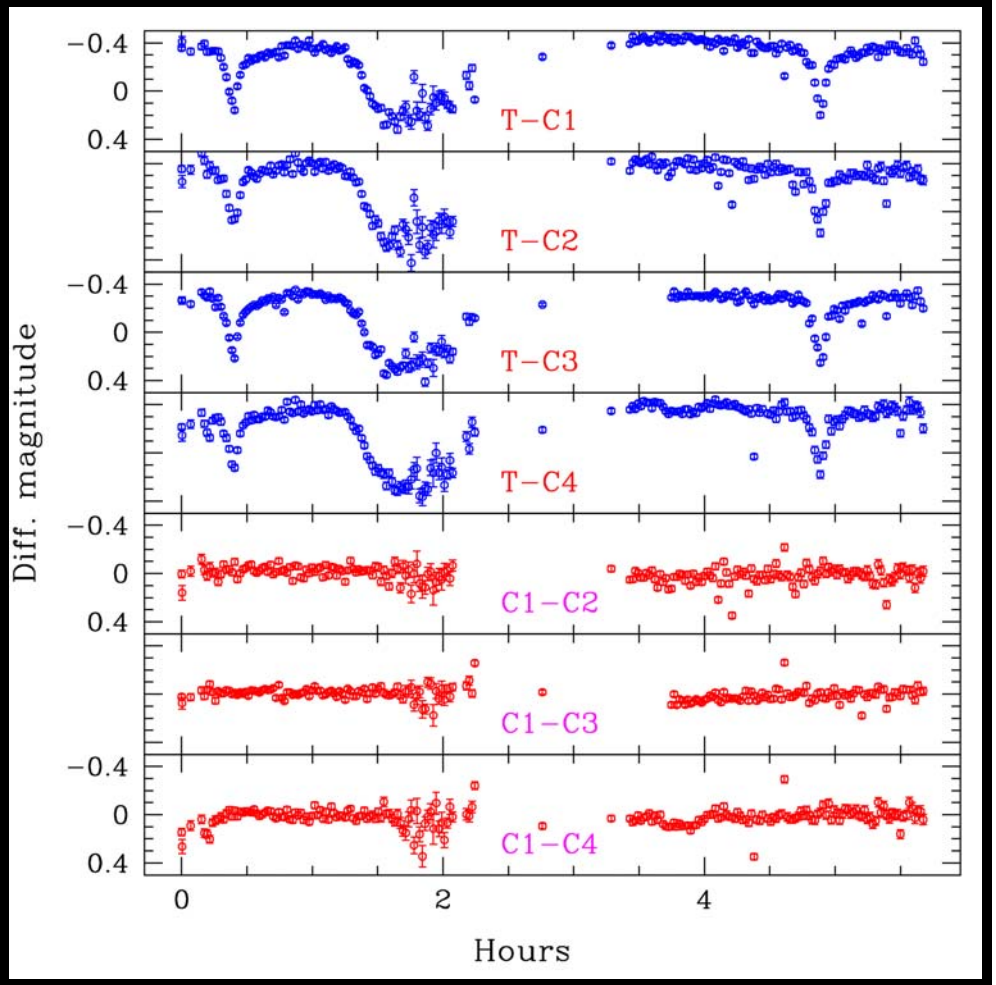
- **Indo-Belgian Projects (DST-BELSPO:2016-2021)**

5. Belgo-India Network on Astronomy & Astrophysics (**PI : S. Joshi**; 2016-2019).

6. Belgo-India Network on Astronomy & Astrophysics: Part-II (**PI : S. Joshi**; 2018-2021).

Monitoring of a Planetory Transit WD1145+07 from 3.6-m DOT





- Exp : 75-sec, Filter : B, Duration of Observation ~ 5.5 hrs, Accuracy : 15 mmag


Thank You