Classification of variable stars in the WFCAM Transit Survey

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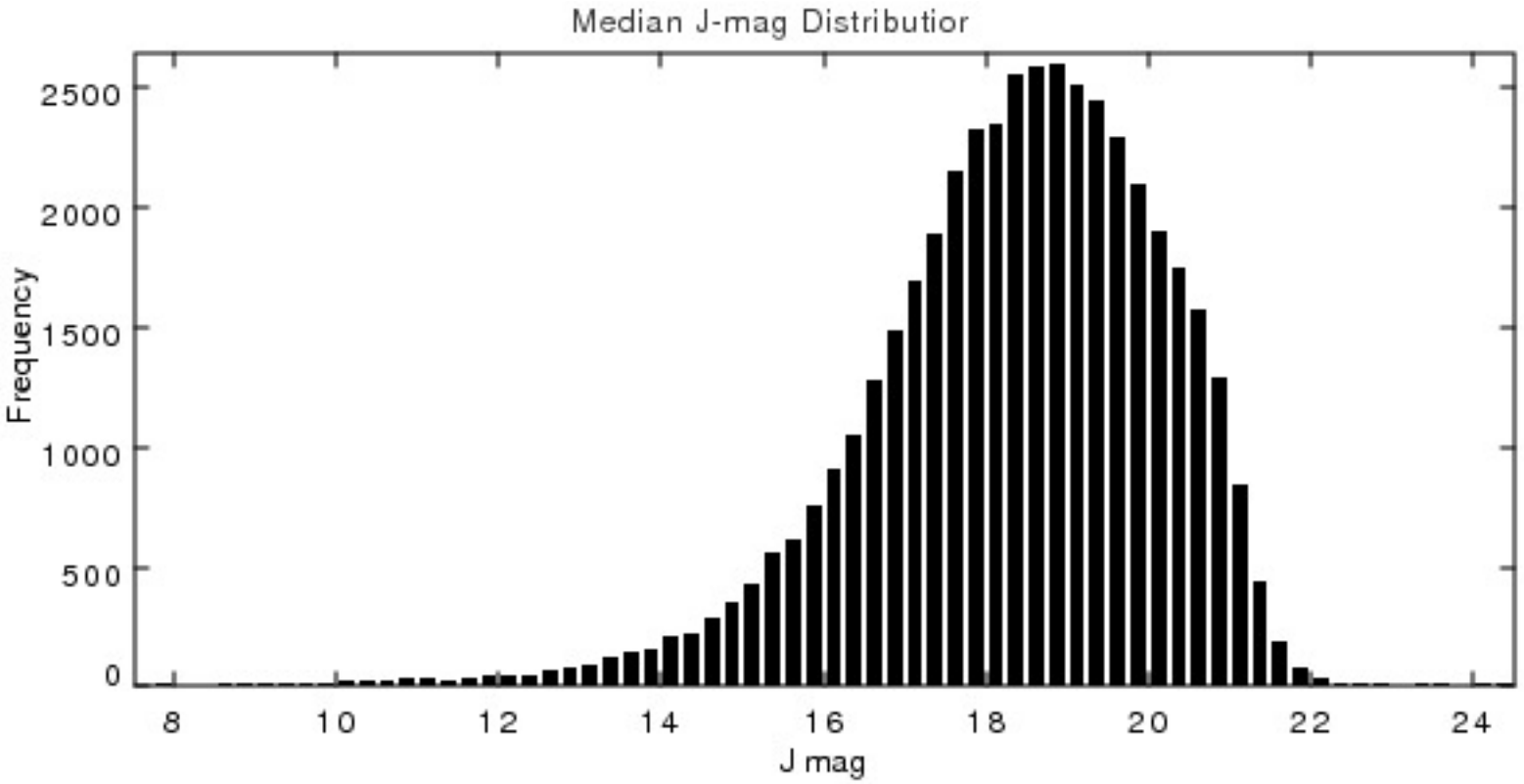
Outline

- Context
- Reduction of the WTS light curves
- Search for significant frequencies: *bossirr* and *freq*
- Classification of variable stars in the WTS 19hr field
- Summary and outlook

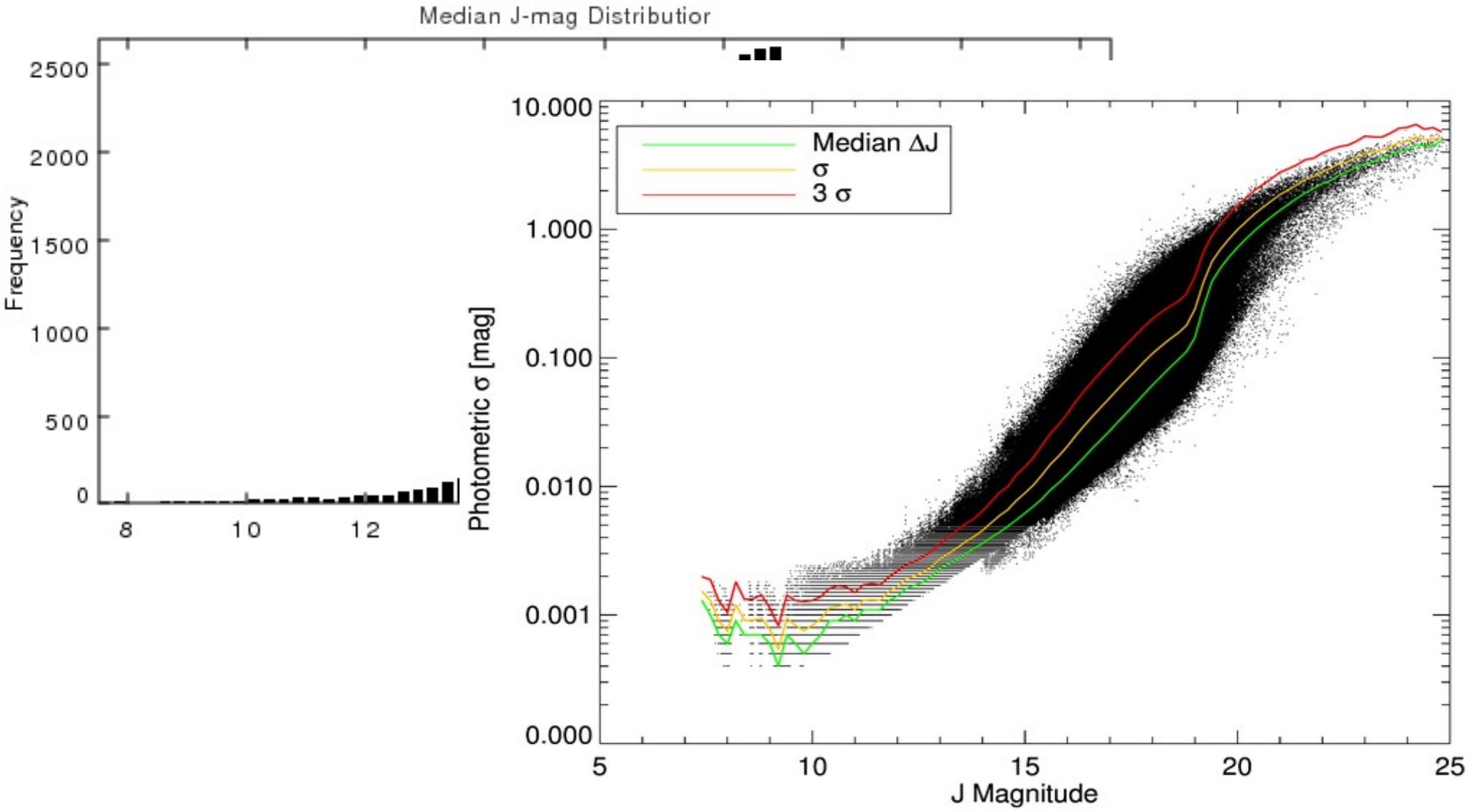
Variable stars are exciting!

- One of the principal areas of astronomical research
- In recent years time-resolved photometric data has marked a boom: OGLE, ASAS, Pan-STARRS, CoRoT, Kepler...
- Soon to come Gaia, VISTA
- All those new variables need to be classified!

Data Characterisation and Reduction of the WTS Light Curves



Data Characterisation and Reduction of the WTS Light Curves



Data Characterisation and Reduction of the WTS Light Curves

- Reject any measurement outside the $\langle J \rangle + 3\sigma(J)$ interval on a light curve by light curve basis
- Reject non-stellar objects, blended objects and objects fainter than the flux limit set in header
- Reject objects fainter than $\langle J \rangle = 19$ mag and with less than 20 data points

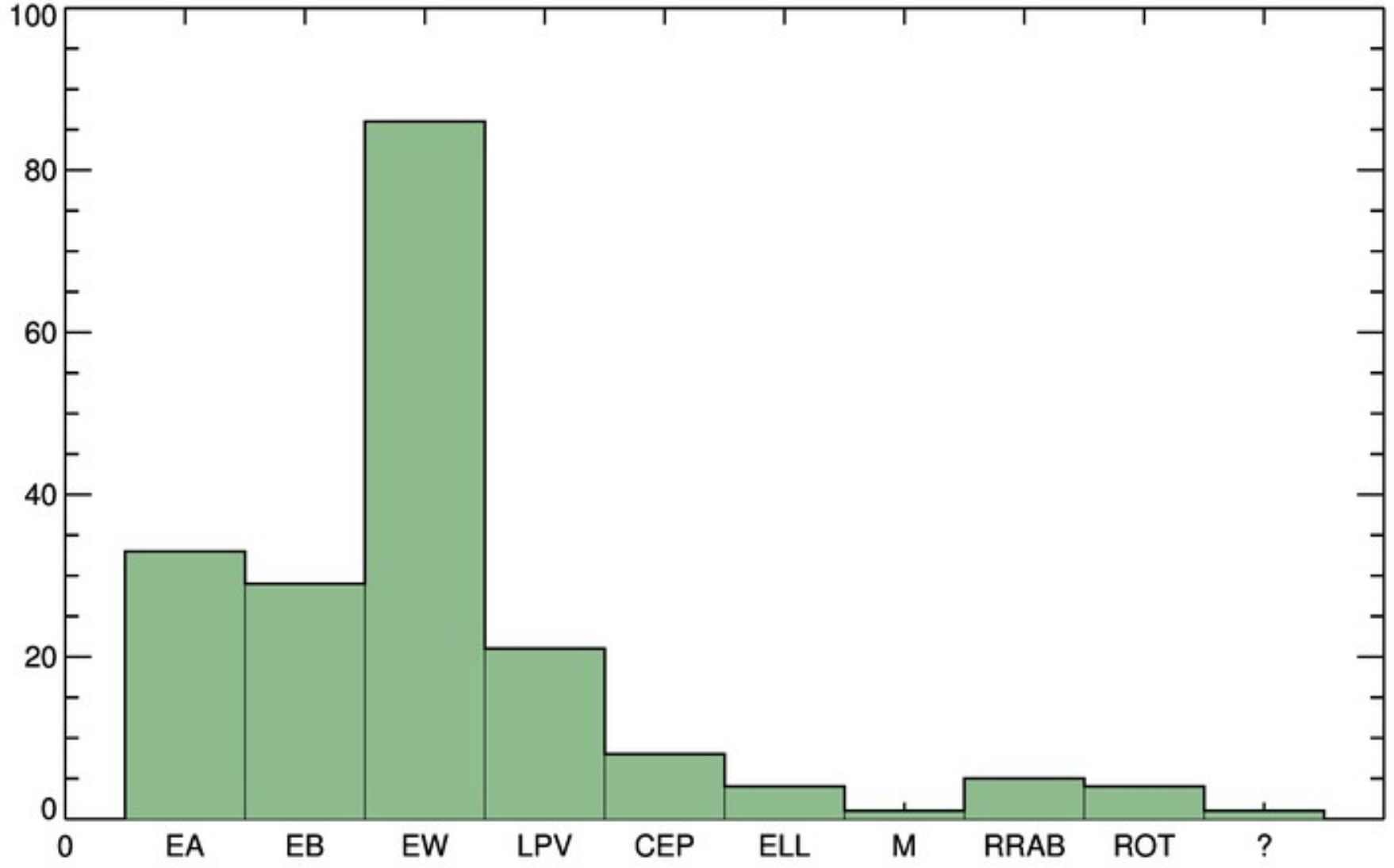
bossirr and *freq*

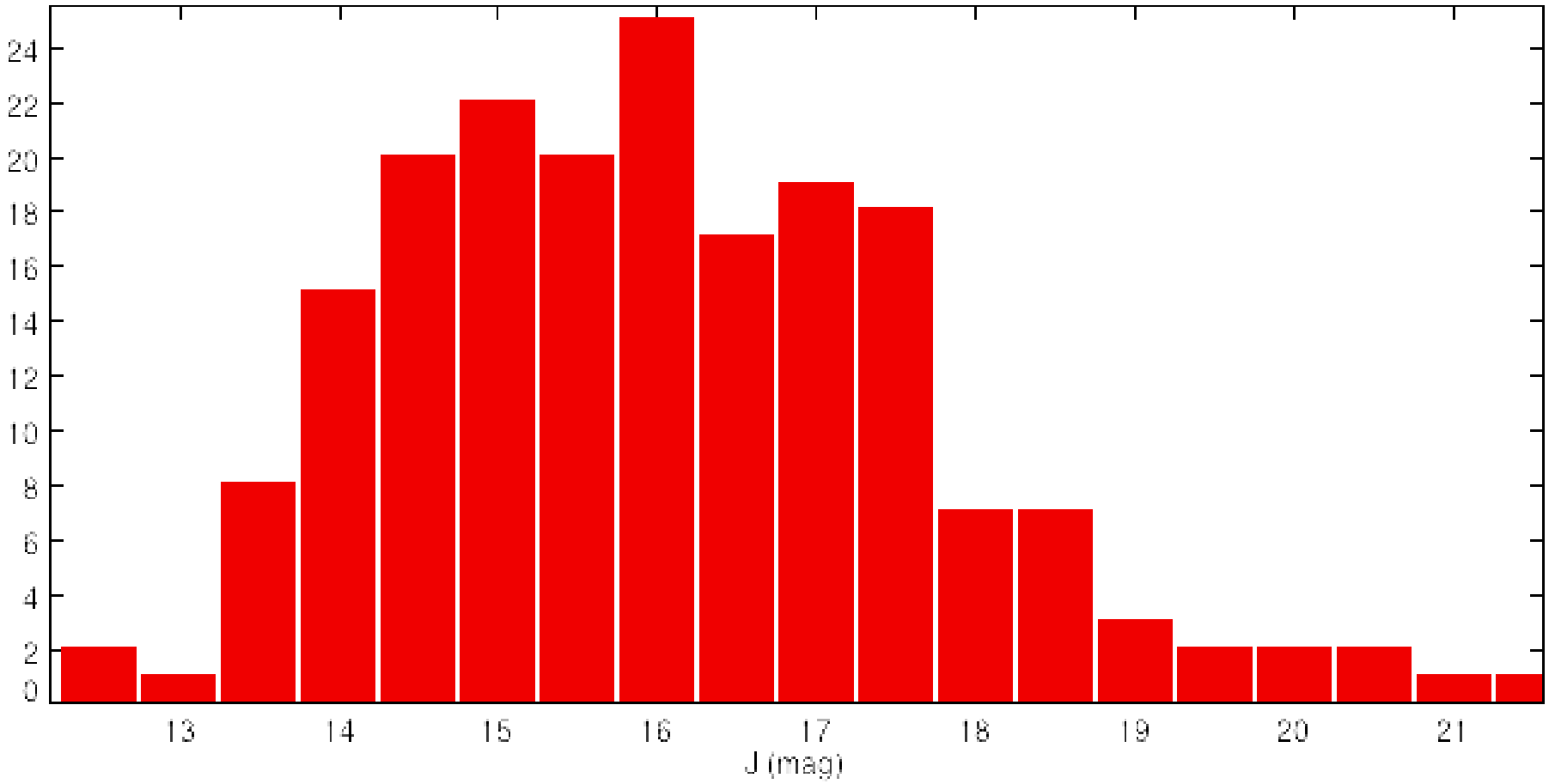
- *bossirr* performs non-linear sinusoidal fits to detect up to two significant frequencies
- *freq, by* least-square fitting, determines with greater precision the detected frequencies and obtains up to four harmonic modes of the form

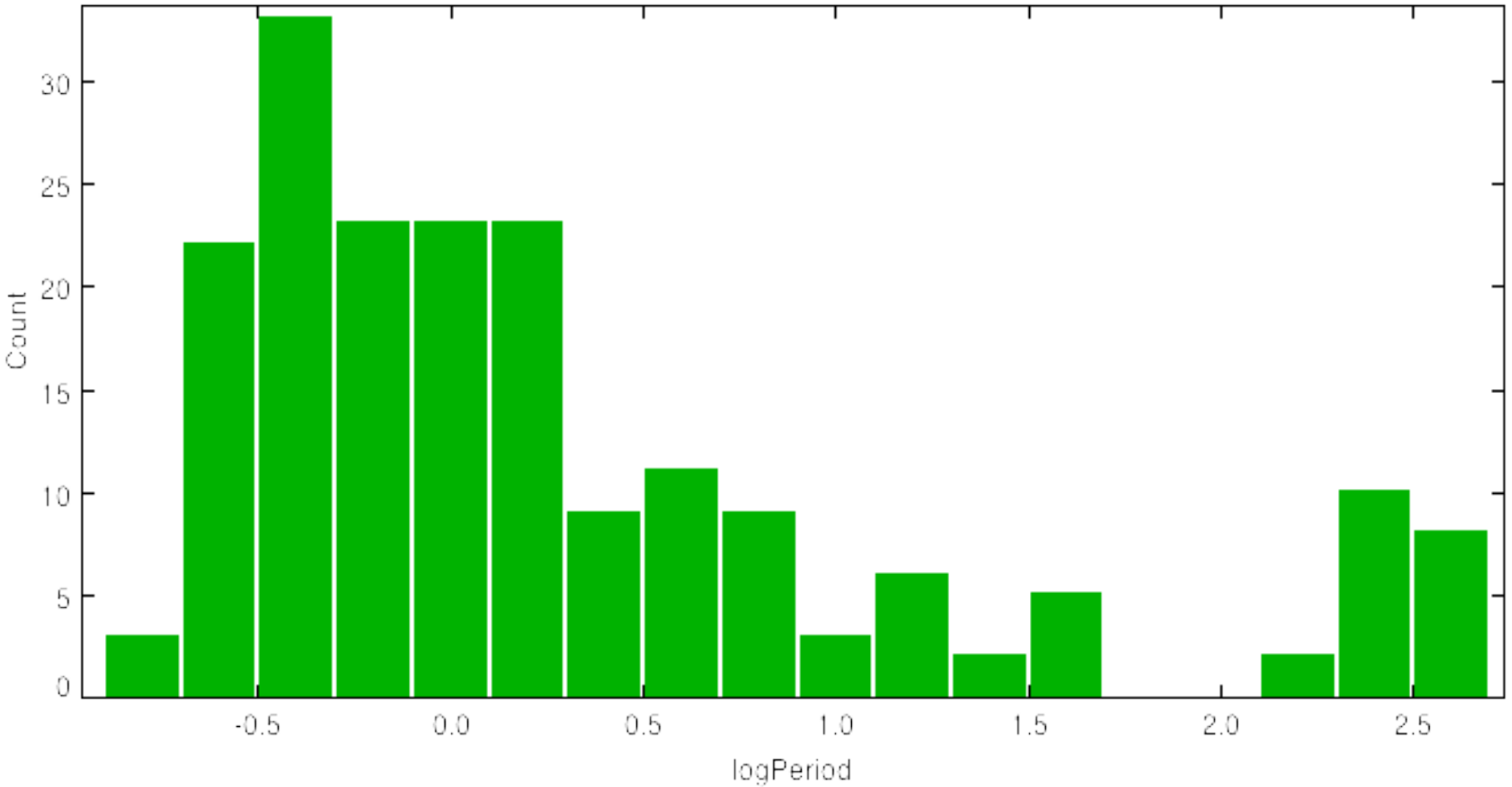
$$f(t) = \sum_{i=1}^{2} \sum_{j=1}^{4} A_{ij} \sin(2\pi f_i j t + \varphi_{ij}) + b_0$$

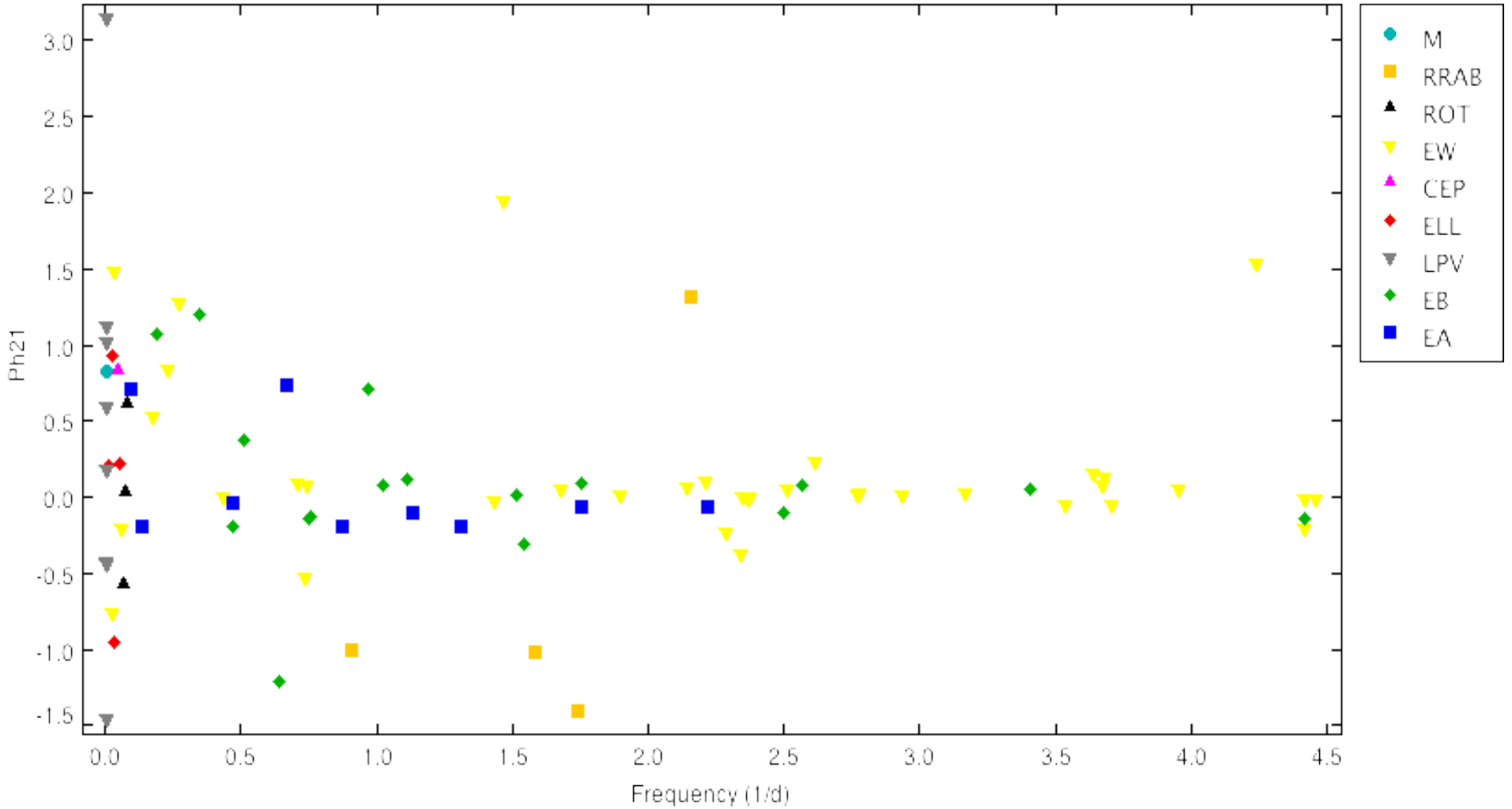
to determine their amplitudes and phases

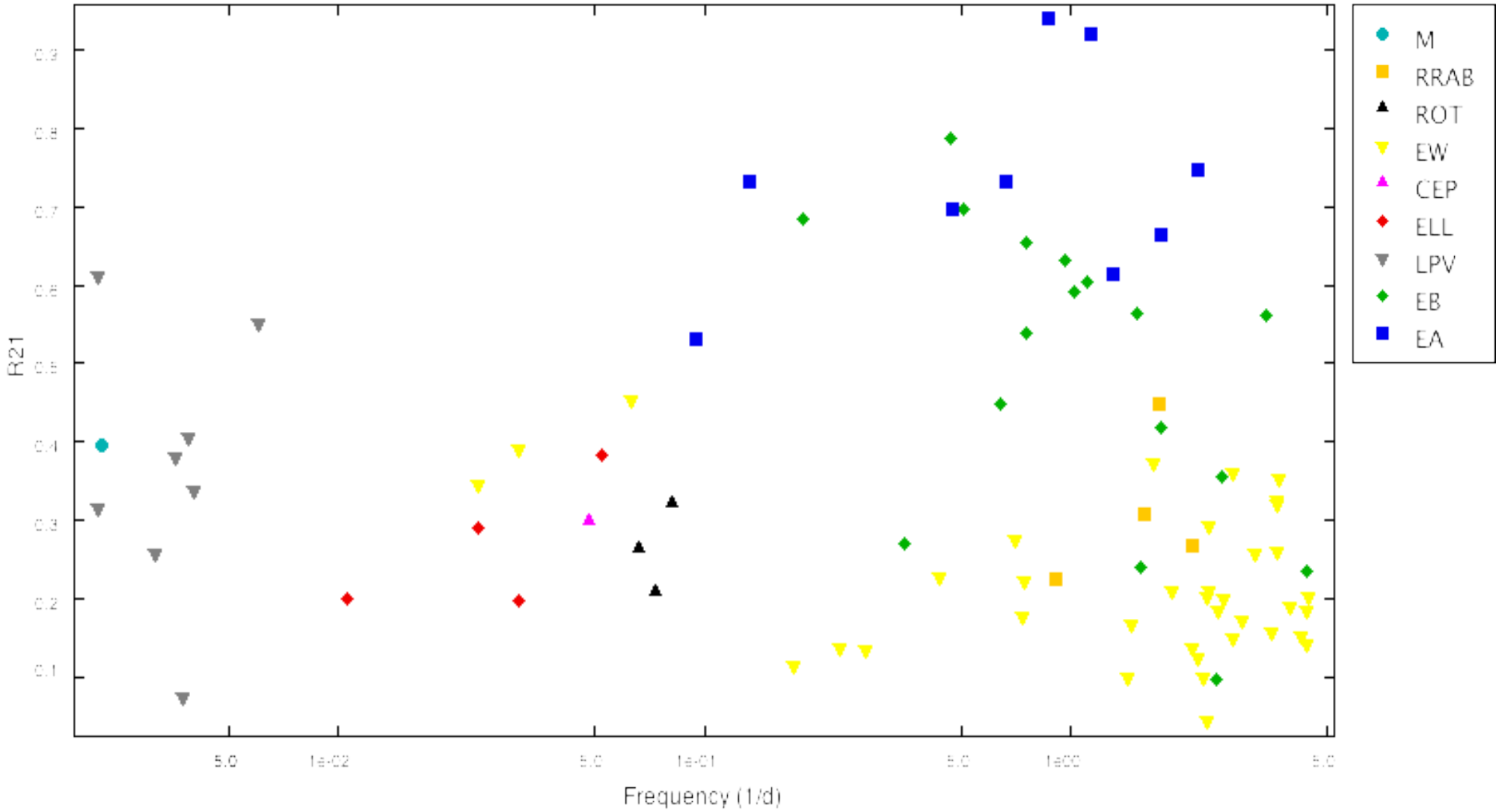
Classification

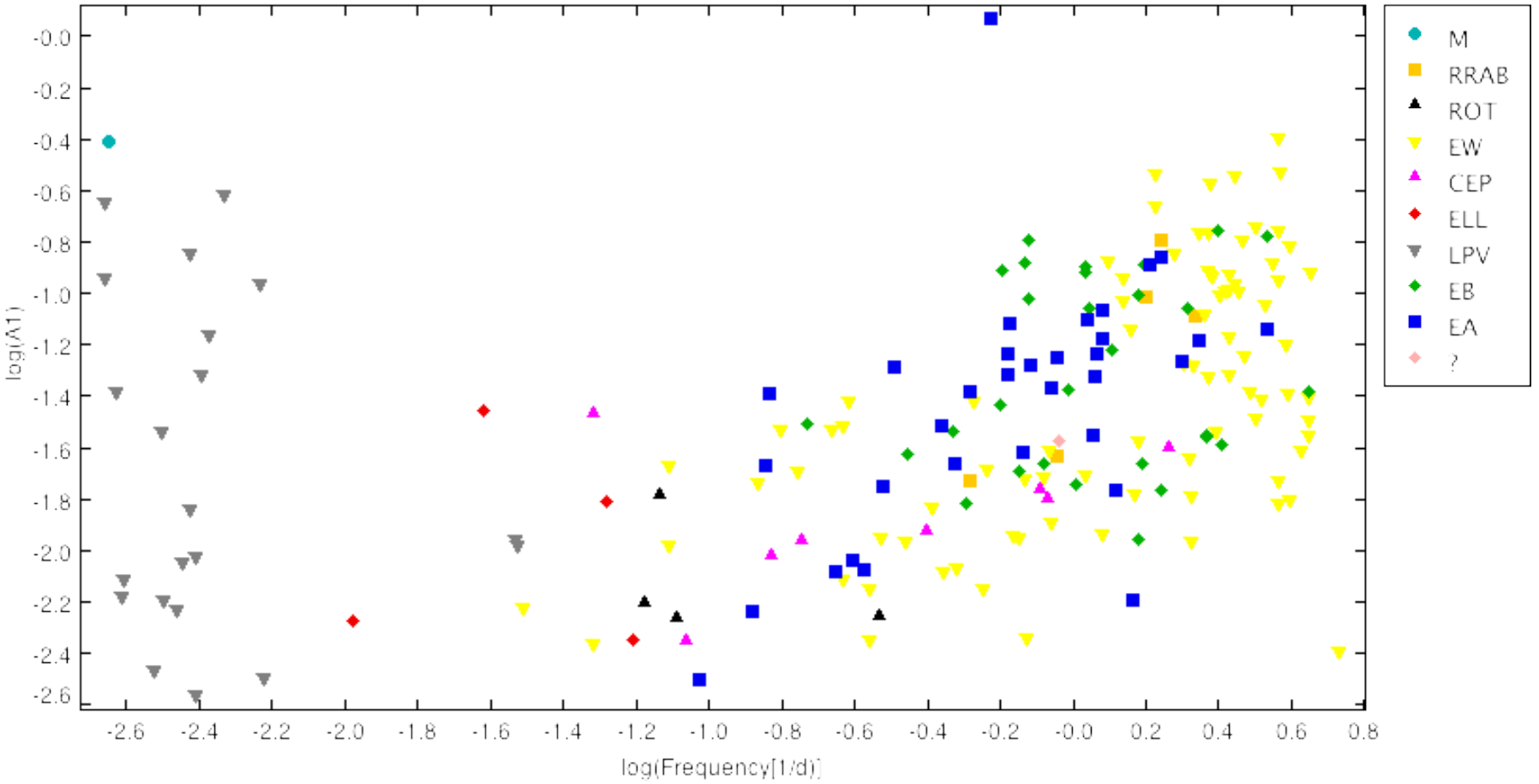


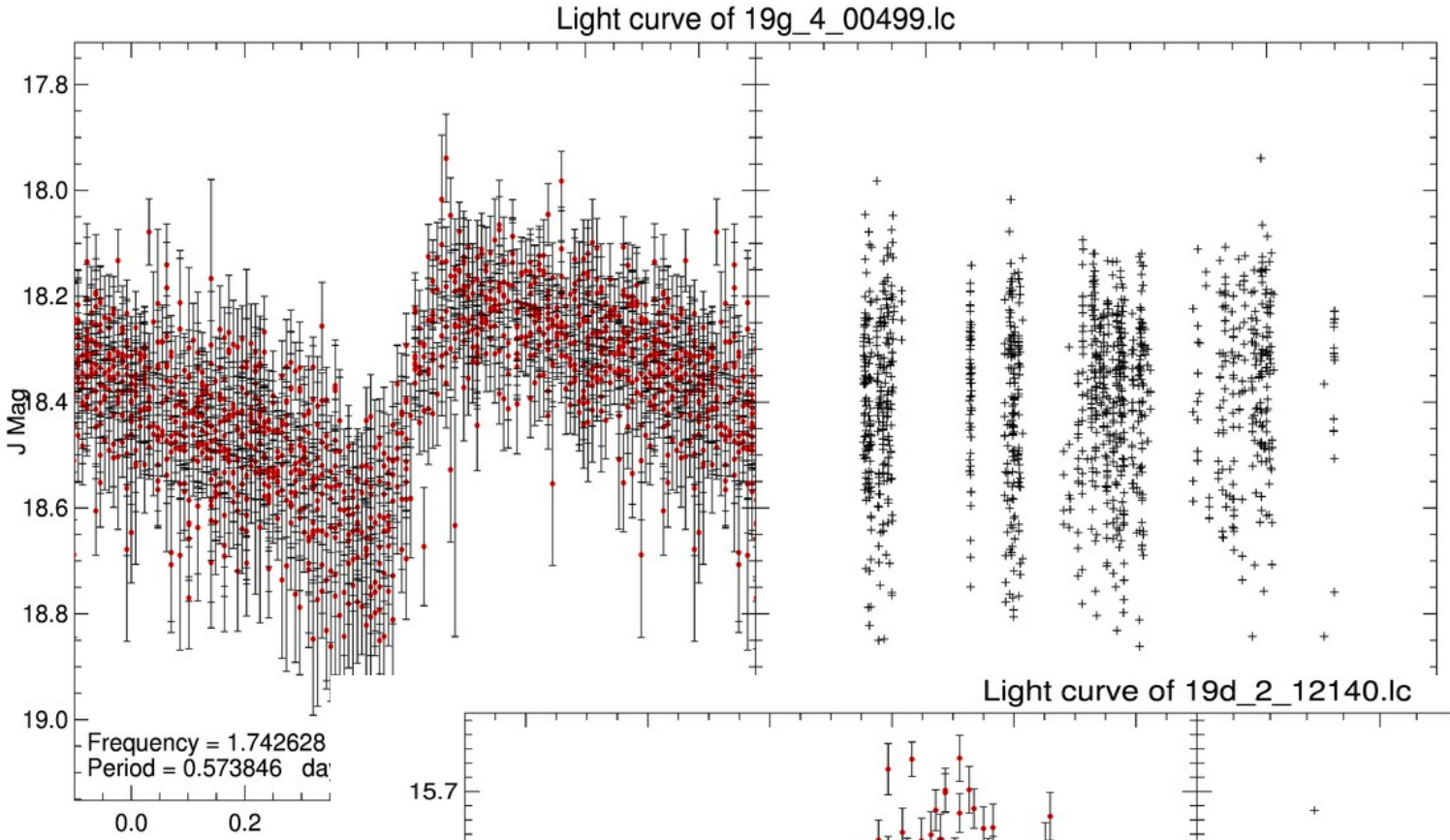

24
22
20
18
16
14
12
10
8
6
4
2
0
13
14
15
16
17
18
19
20
21
J (mag)


Count
30
25
20
15
10
5
0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
logPeriod

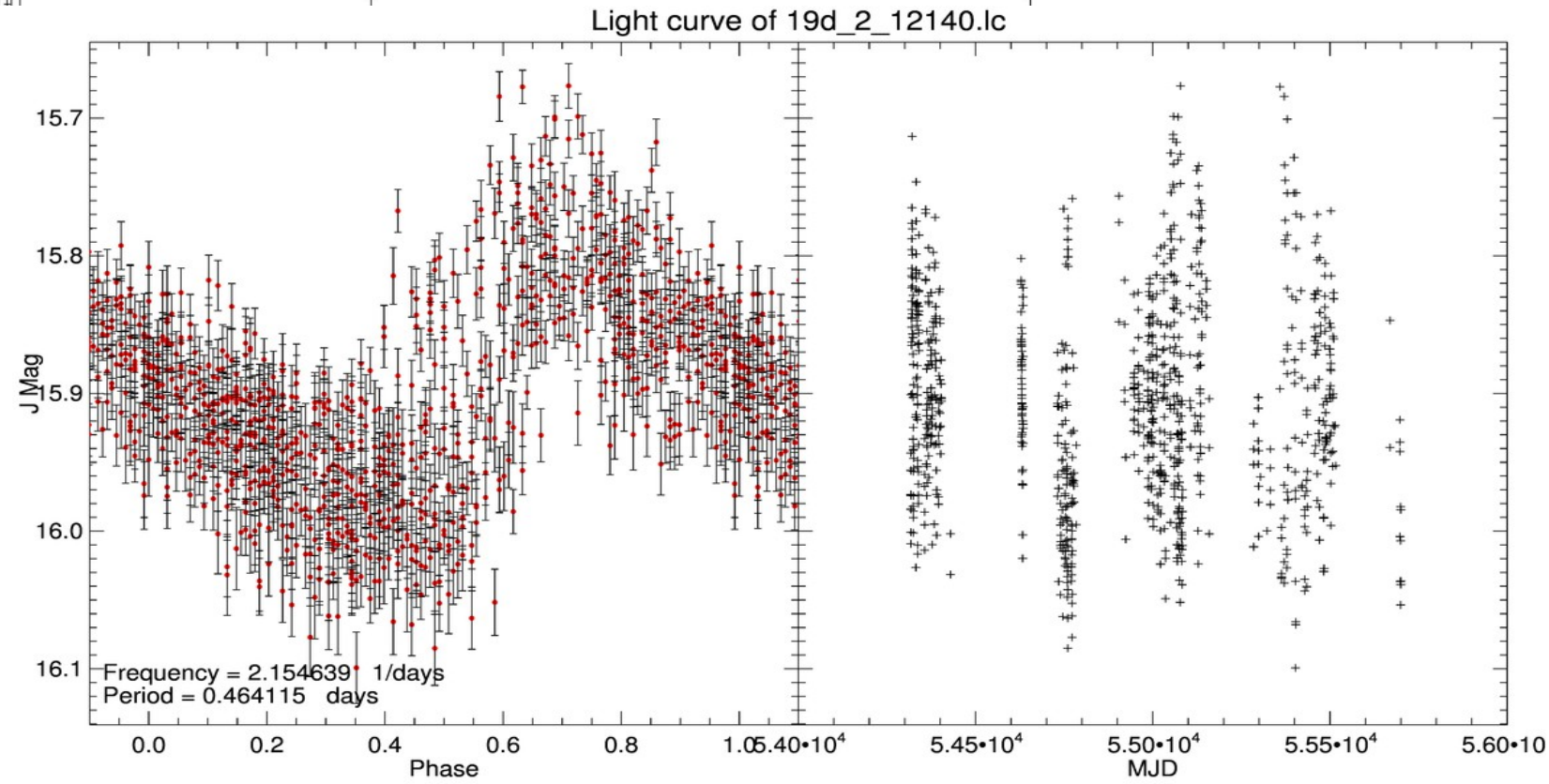

Ph21
Frequency (1/d)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
M
RRAB
ROT
EW
CEP
ELL
LPV
EB
EA

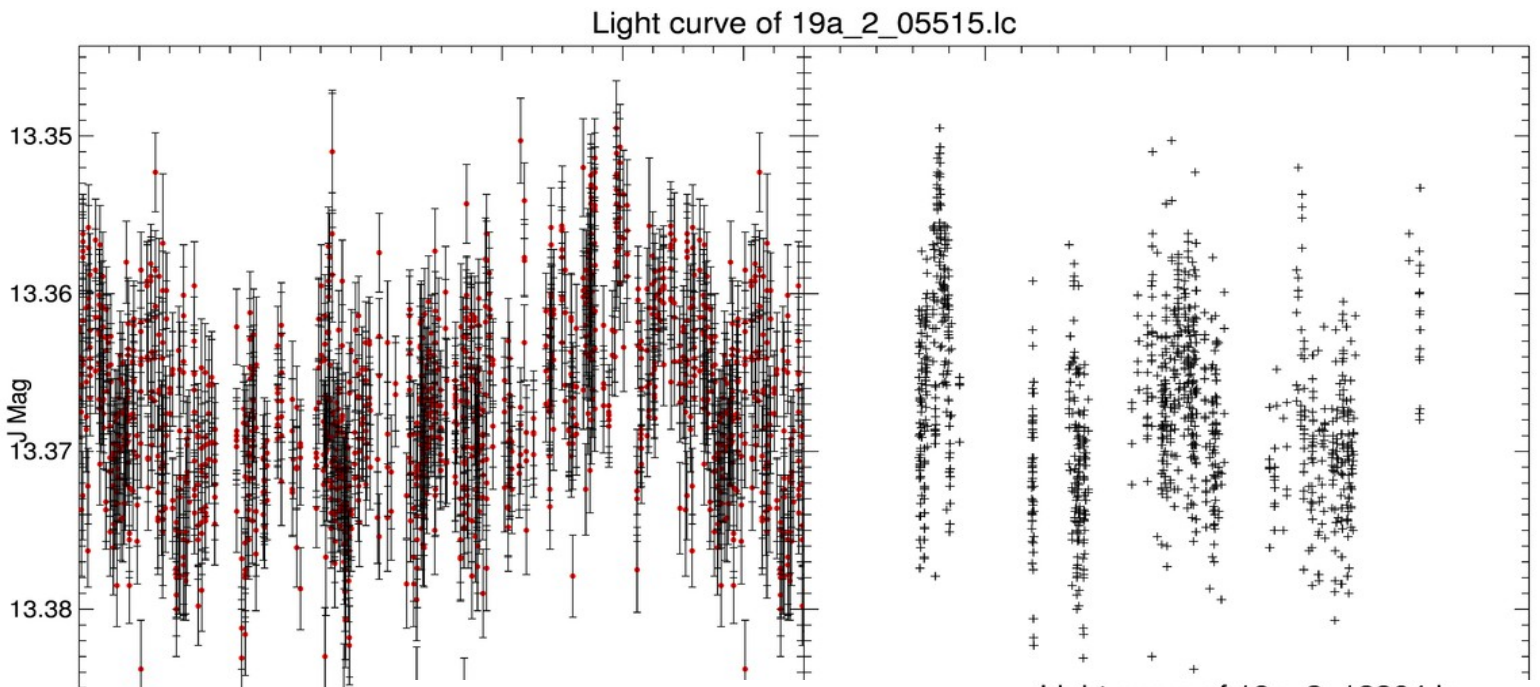

R21
Frequency (1/d)
M
RRAB
ROT
EW
CEP
ELL
LPV
EB
EA


log(A1)
log(Frequency[1/d])
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.6
-2.4
-2.2
-2.0
-1.8
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
-0.0
0.2
0.4
0.6
0.8
M
RRAB
ROT
EW
CEP
ELL
LPV
EB
EA
?

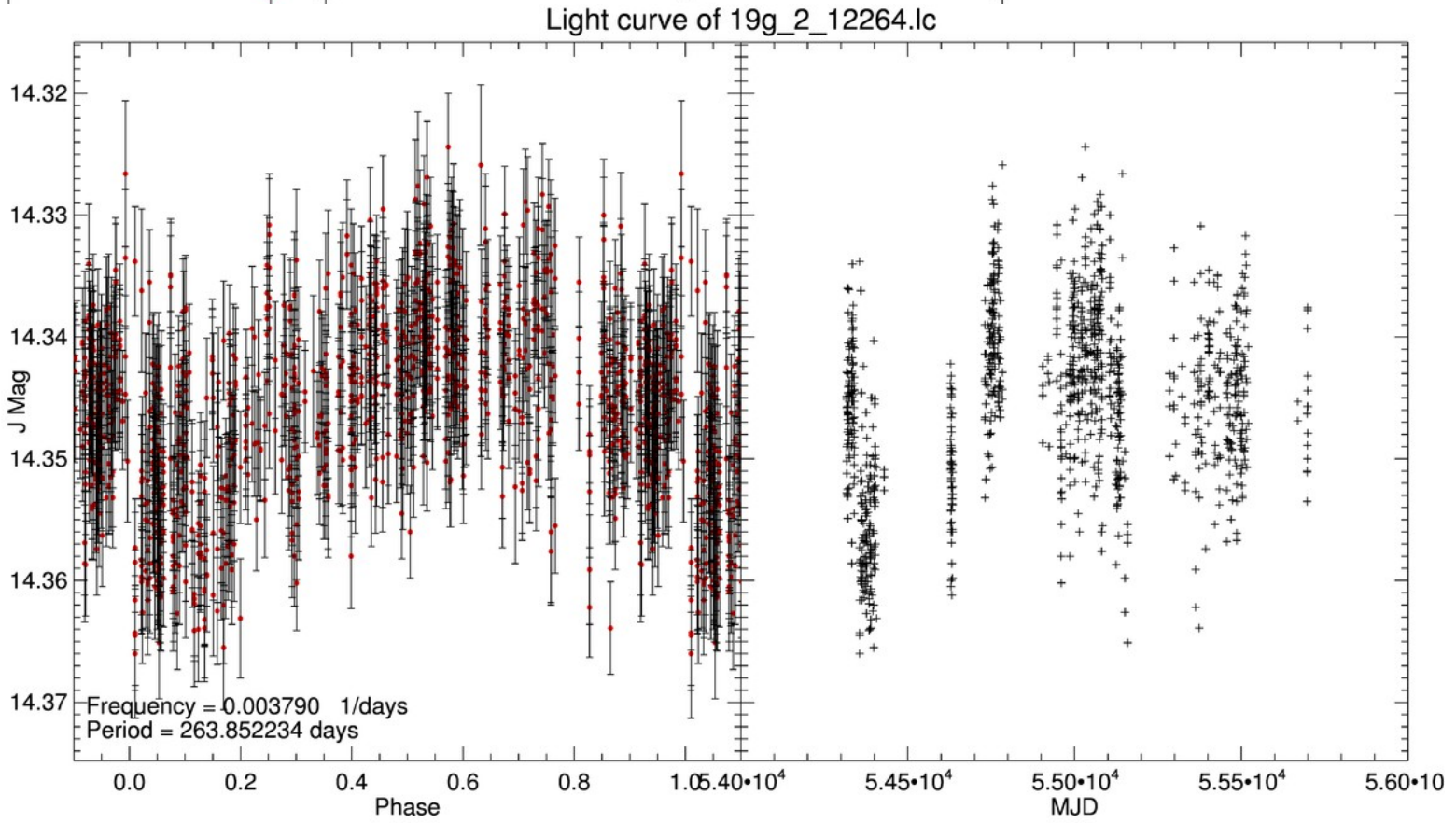

Light curve of 19g_4_00499.lc
J Mag
17.8
18.0
18.2
18.4
18.6
18.8
19.0
Frequency = 1.742628
Period = 0.573846 da
0.0
0.2

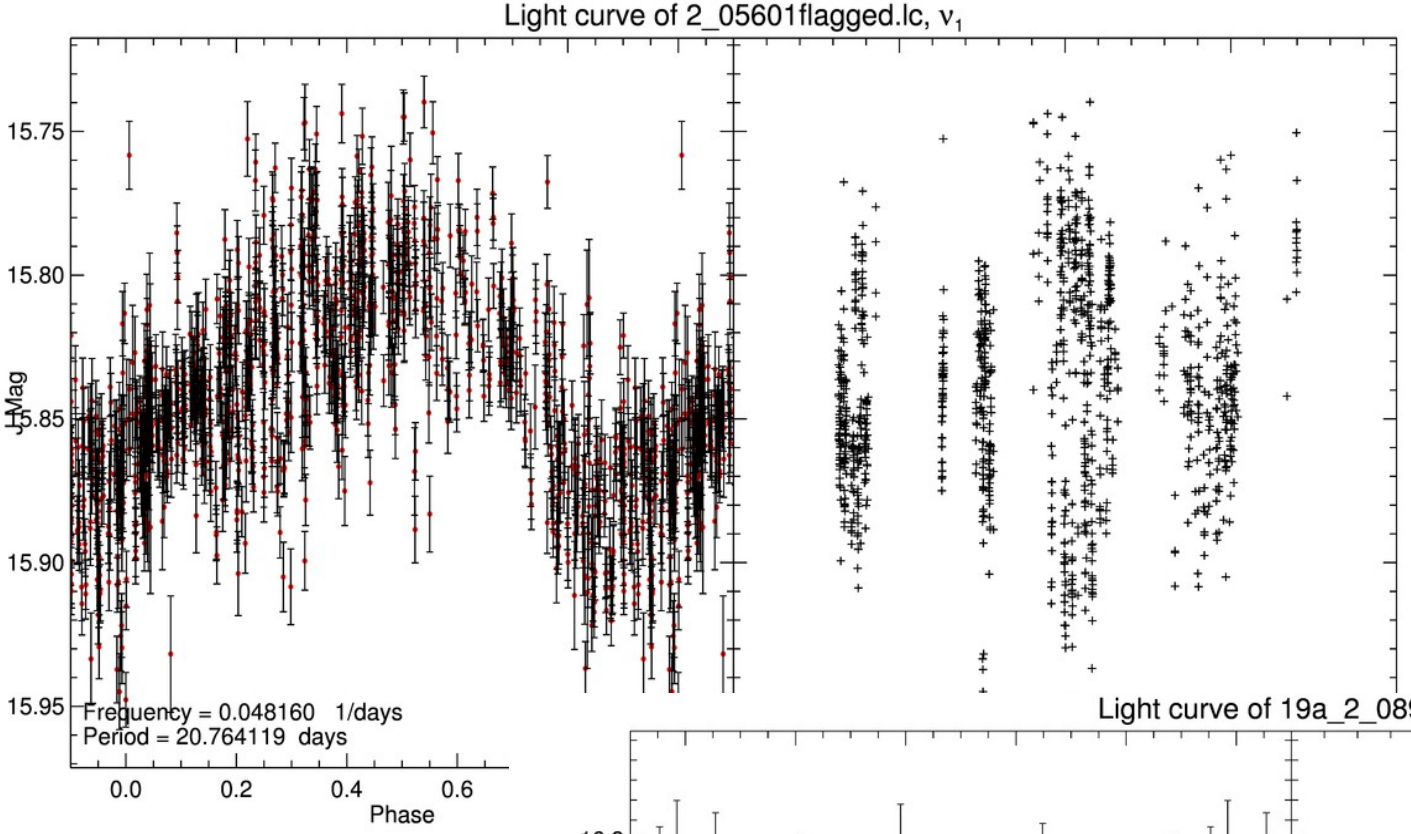
RRAB


Light curve of 19d_2_12140.lc
J Mag
15.7
15.8
15.9
16.0
16.1
Frequency = 2.154639 1/days
Period = 0.464115 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD

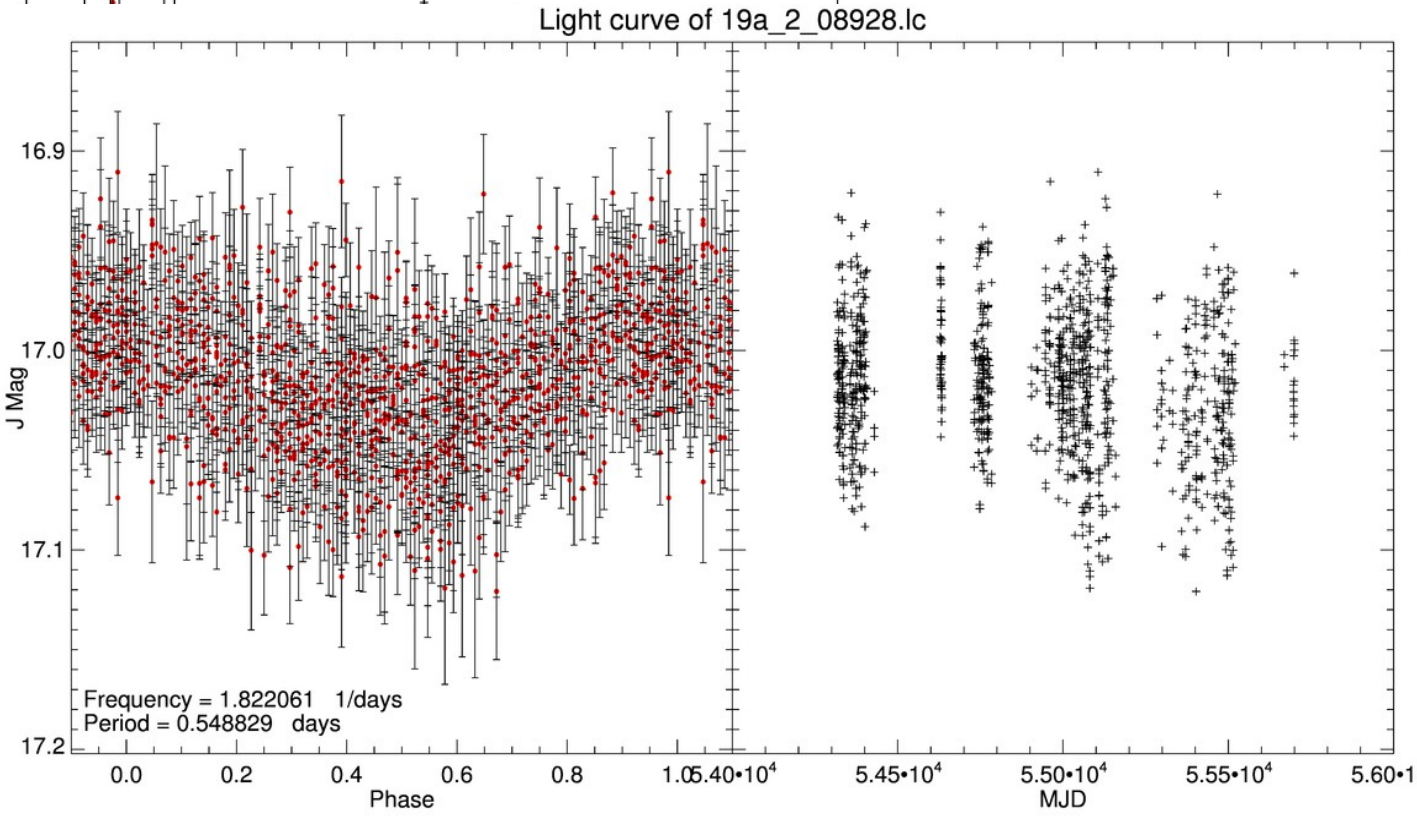

Light curve of 19a_2_05515.lc
J Mag
13.35
13.36
13.37
13.38
13.39
Frequency = 0.006010 1/d
Period = 166.389343 days
0.0
0.2
0.4

LPV

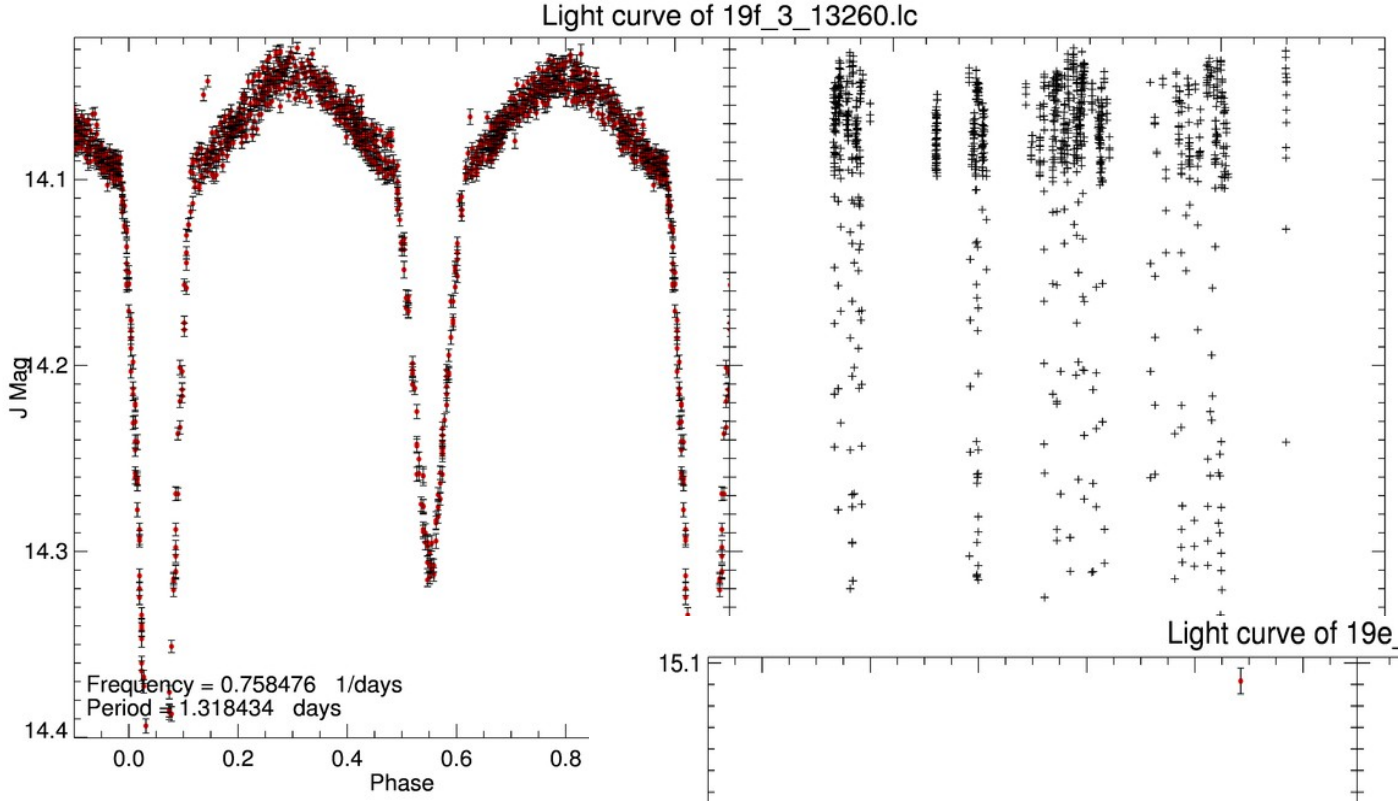

Light curve of 19g_2_12264.lc
J Mag
14.32
14.33
14.34
14.35
14.36
14.37
Frequency = 0.003790 1/days
Period = 263.852234 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD

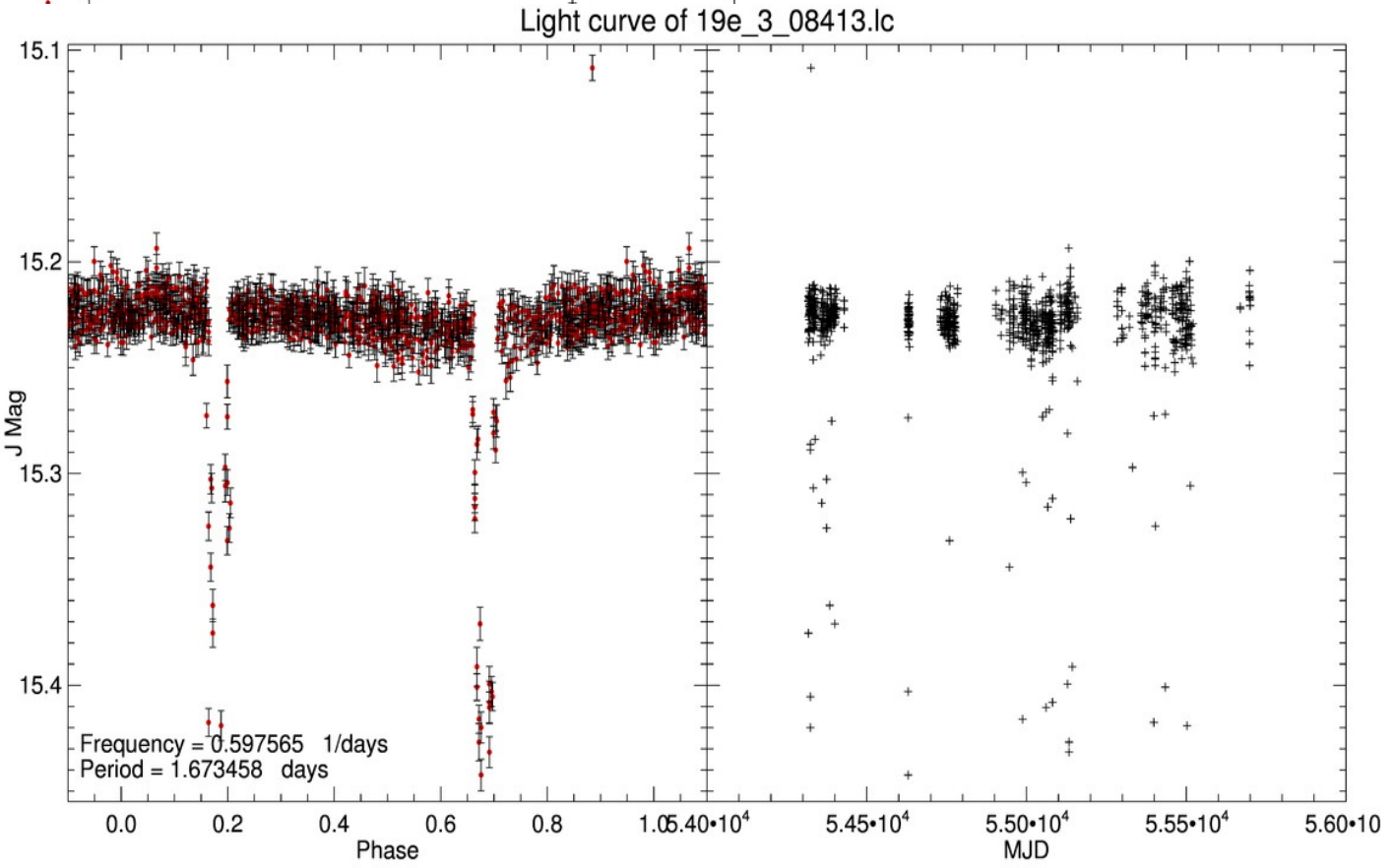

Light curve of 2_05601flagged.lc, ν1
15.75
15.80
15.85
15.90
15.95
J Mag
Frequency = 0.048160 1/days
Period = 20.764119 days
0.0
0.2
0.4
0.6
Phase

CEP

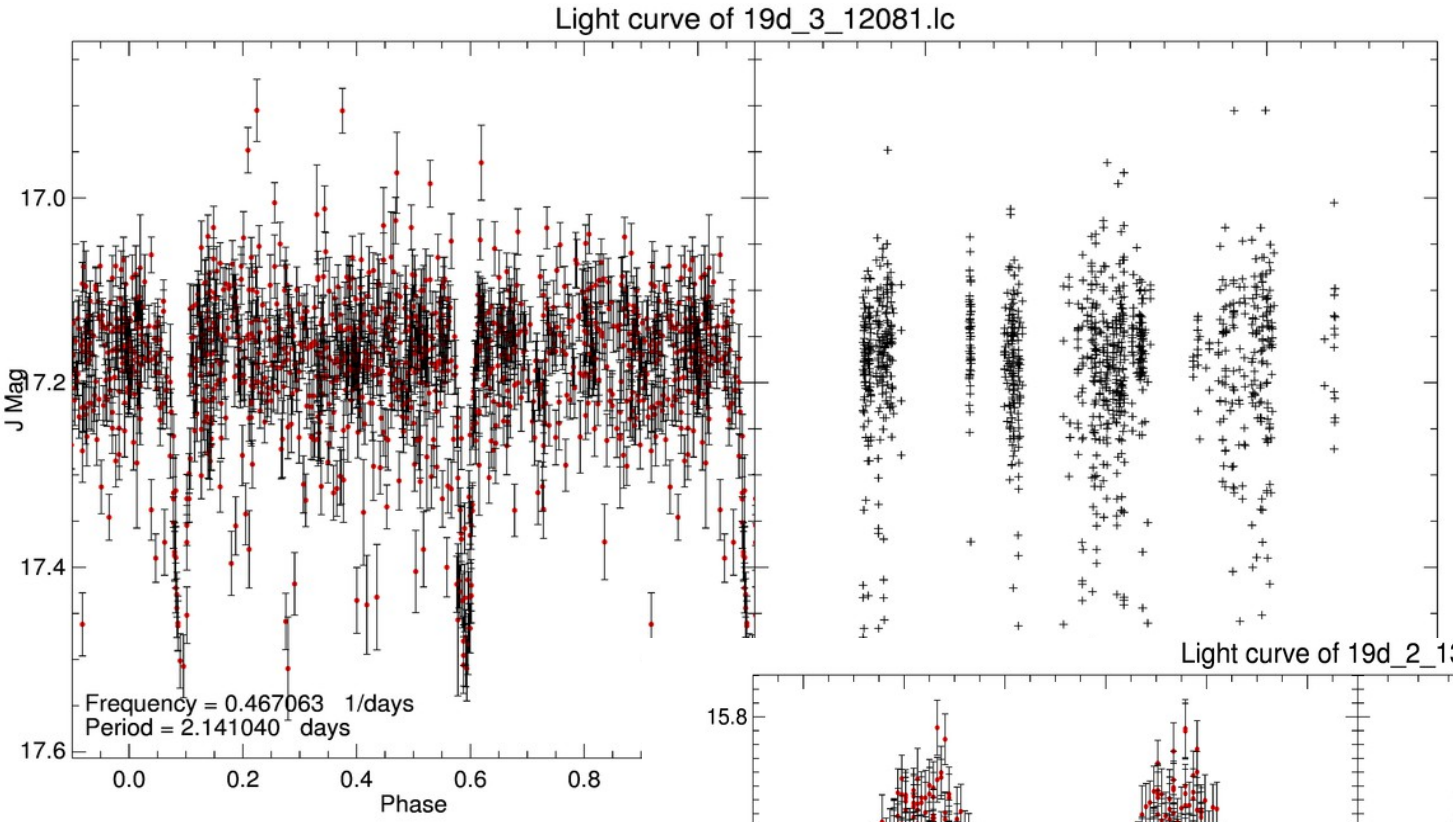

Light curve of 19a_2_08928.lc
16.9
17.0
17.1
17.2
J Mag
Frequency = 1.822061 1/days
Period = 0.548829 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD

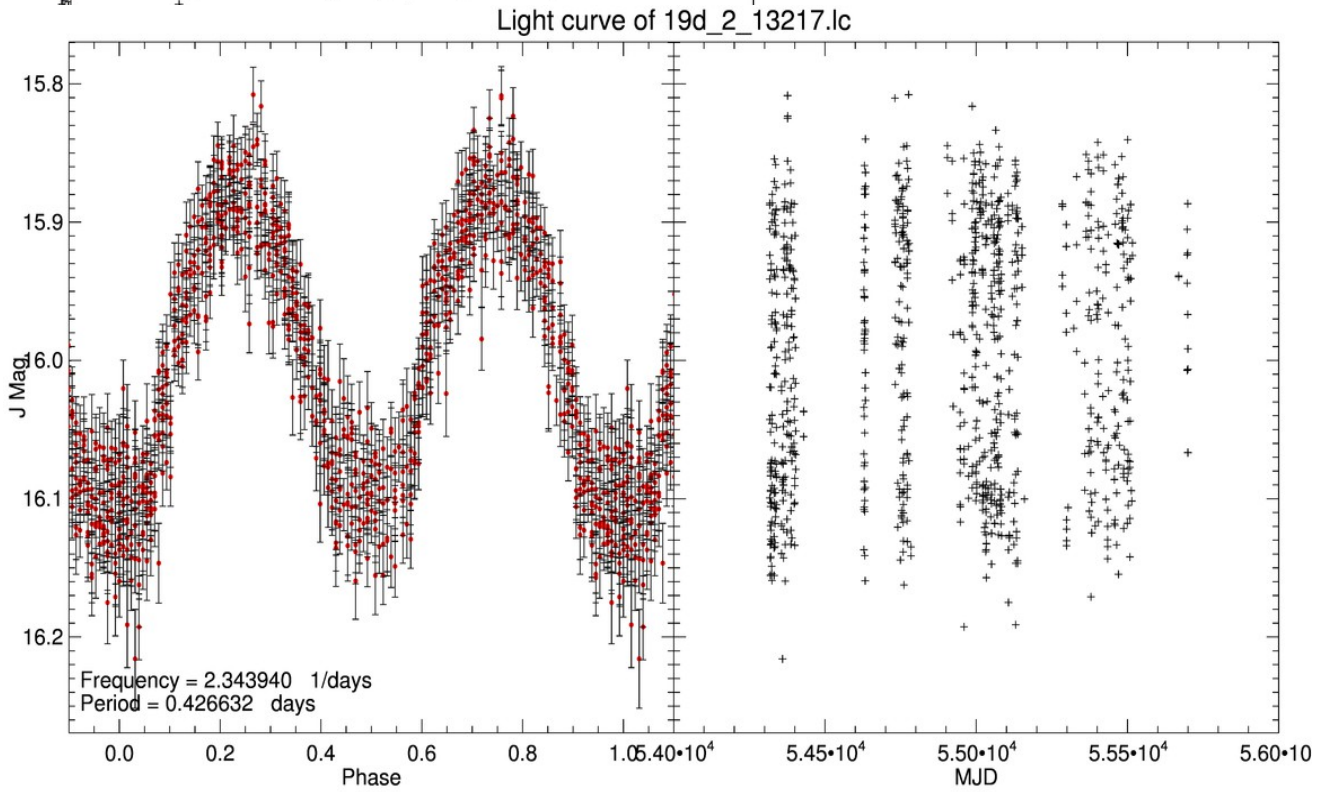
EA EB EW


Light curve of 19f_3_13260.lc
J Mag
14.1
14.2
14.3
14.4
Frequency = 0.758476 1/days
Period = 1.318434 days
0.0
0.2
0.4
0.6
0.8
Phase


Light curve of 19e_3_08413.lc
J Mag
15.1
15.2
15.3
15.4
Frequency = 0.597565 1/days
Period = 1.673458 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD

EA EB EW


Light curve of 19d_3_12081.lc
J Mag
17.0
17.2
17.4
17.6
Frequency = 0.467063 1/days
Period = 2.141040 days
0.0
0.2
0.4
0.6
0.8
Phase


Light curve of 19d_2_13217.lc
J Mag
15.8
15.9
16.0
16.1
16.2
Frequency = 2.343940 1/days
Period = 0.426632 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD

Summary

- 185 new classified variable stars detected
  - Another seven EWs already in VSX catalogue
- To be used for the classification of the rest of the WTS fields
- WTS to produce a complete training set for variable star classification in the nIR

Thank you!

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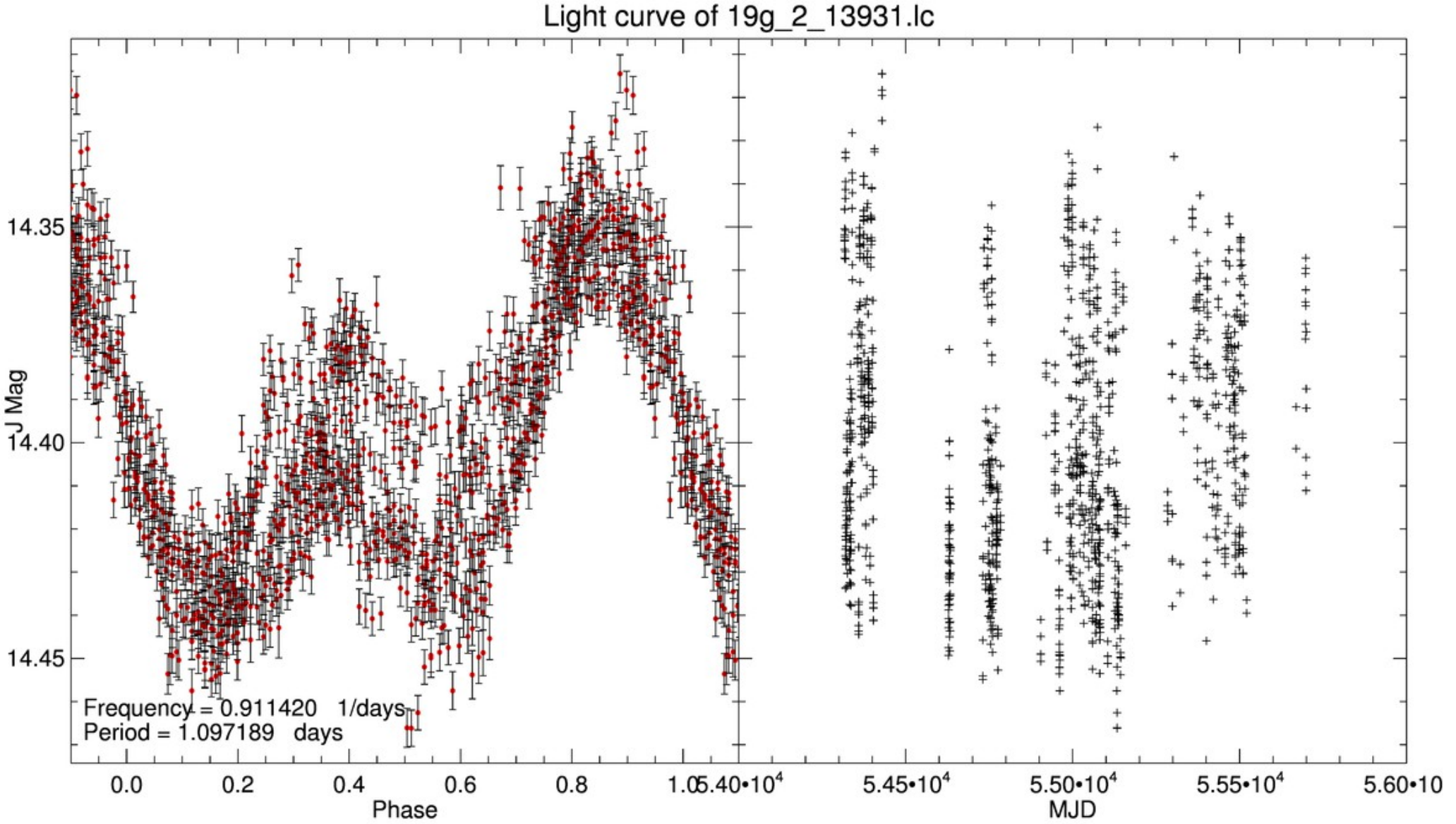
Light curve of 19g_2_13931.lc
J Mag
14.35
14.40
14.45
Frequency = 0.911420 1/days
Period = 1.097189 days
0.0
0.2
0.4
0.6
0.8
1.0
Phase
5.40•10^4
5.45•10^4
5.50•10^4
5.55•10^4
5.60•10
MJD