

**Papers published in 2024**

- **„Pulsation Modelling of the Cepheid Y Ophiuchi with RSP/MESA. Impact of Circumstellar Envelope and a High Projection Factor on Baade-Wesselink Method”,** V. Hecdé, R. Smolec, P. Moskalik, R. Singh Rathour & O. Ziółkowska, 2024, A&A, 683, A233.
- **„Double-Mode RR Lyrae Stars Observed by K2: Analysis of High-Precision *Kepler* Photometry”,** J. M. Nemec, A. F. Linnell Nemec, P. Moskalik, L. Molnár, E. Plachy, R. Szabó & K. Kolenberg, 2024, MNRAS, 529, 296.
- **„Precise Fourier Parameters of Cepheid Radial Velocity Curves”,** V. Hecdé, P. Moskalik, N. A. Gorynya, R. Smolec, R. Singh Rathour & O. Ziółkowska, 2024, A&A, 689, A224.
- **„Why Y Oph is off ? Pulsation Modelling of the Cepheid Y Ophiuchi with MESA/RSP”,** V. Hecdé, R. Smolec, P. Moskalik, 2024, SP2A-24: Proceedings of the Annual Meeting of the French Society of Astronomy & Astrophysics, p. 77.

# **Precise Fourier Parameters of Cepheid Radial Velocity Curves**

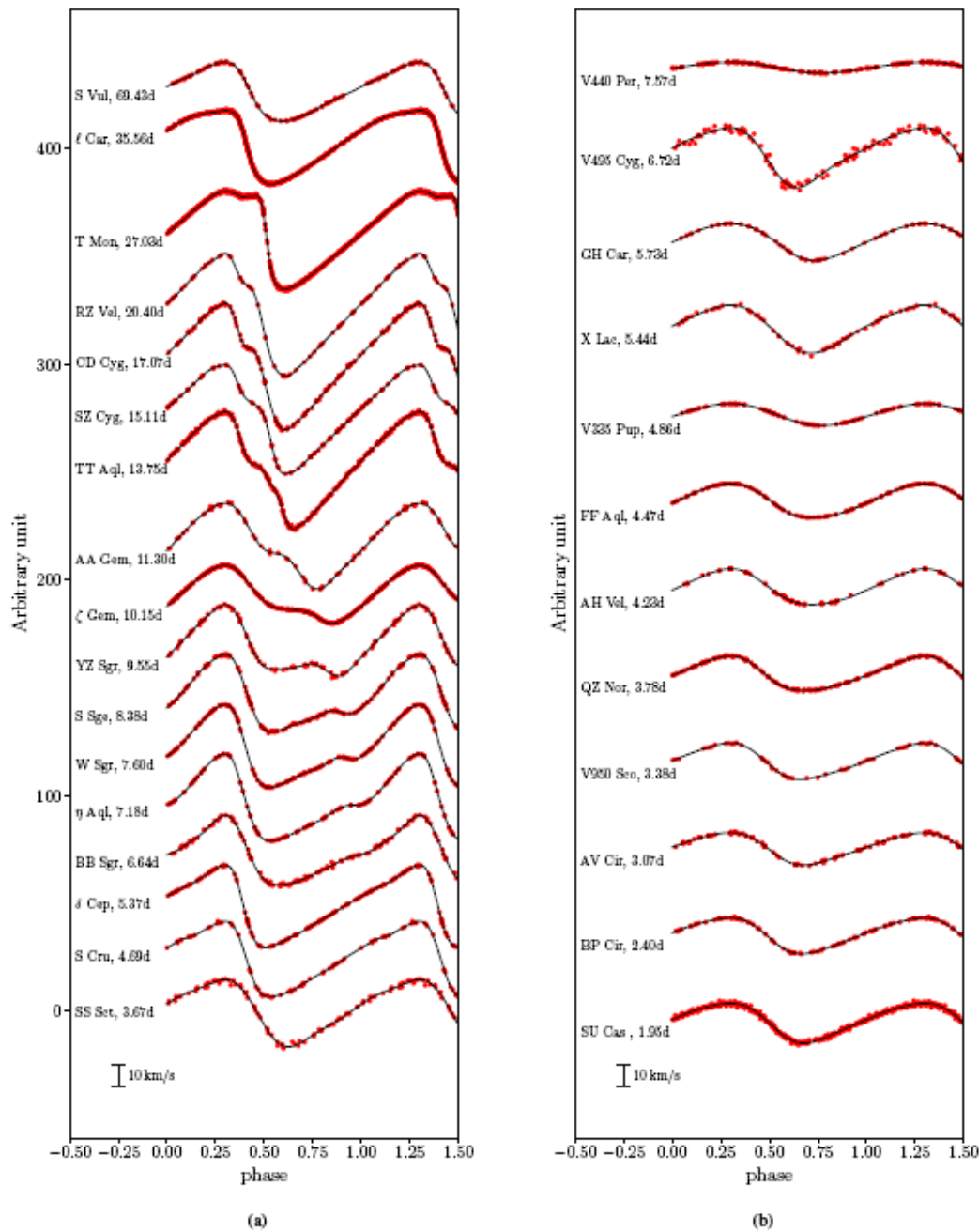
## 218 single-mode Cepheids

- 178 FU
- 33 FO

$$V_r(t) = A_0 + \Sigma A_k \sin(k\omega t + \phi_k)$$

$$R_{k1} = A_k/A_1$$

$$\phi_{k1} = \phi_k - k\phi_1$$



## 218 single-mode Cepheids

- 178 FU

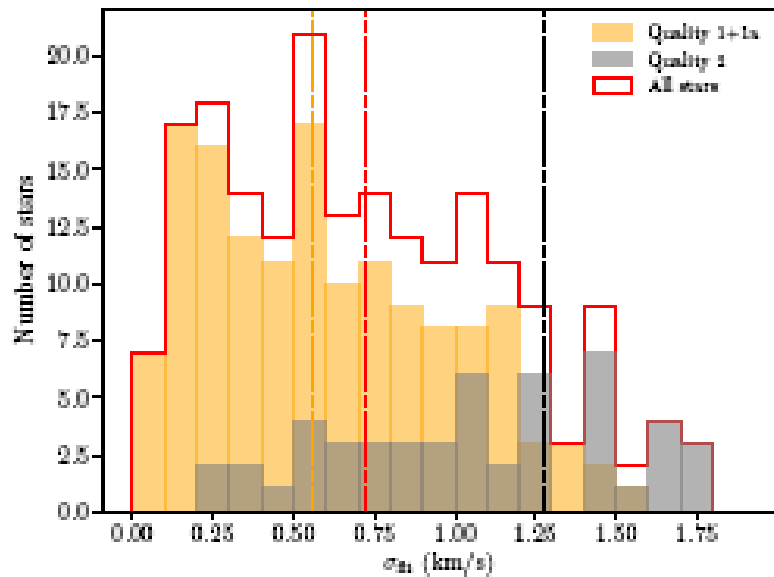
- 33 FO

$$V_r(t) = A_0 + \sum A_k \sin(k\omega t + \phi_k)$$

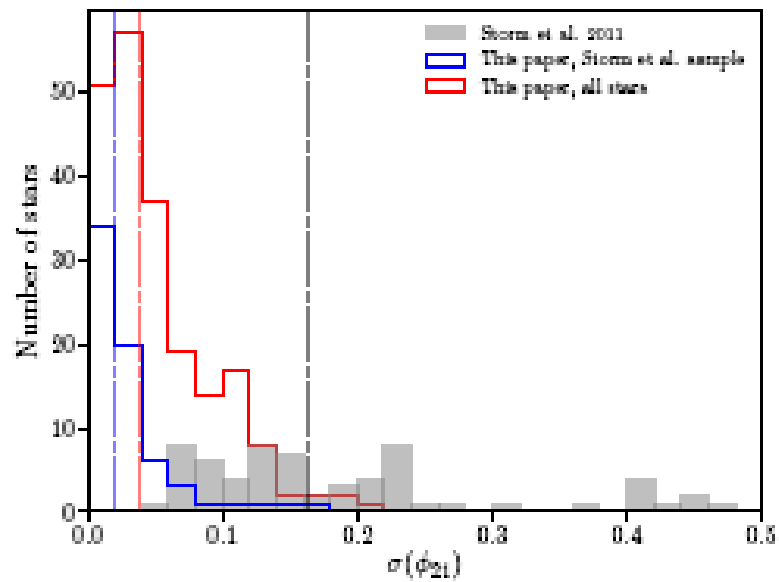
$$R_{k1} = A_k/A_1$$

$$\phi_{k1} = \phi_k - k\phi_1$$

Fig. 1: Radial velocity curves and Fourier fits for a set of fundamental-mode (a) and first-overtone Cepheids (b). The scale is indicated in the left bottom corner of the plots.



(a)



(c)

## Median $\sigma$ :

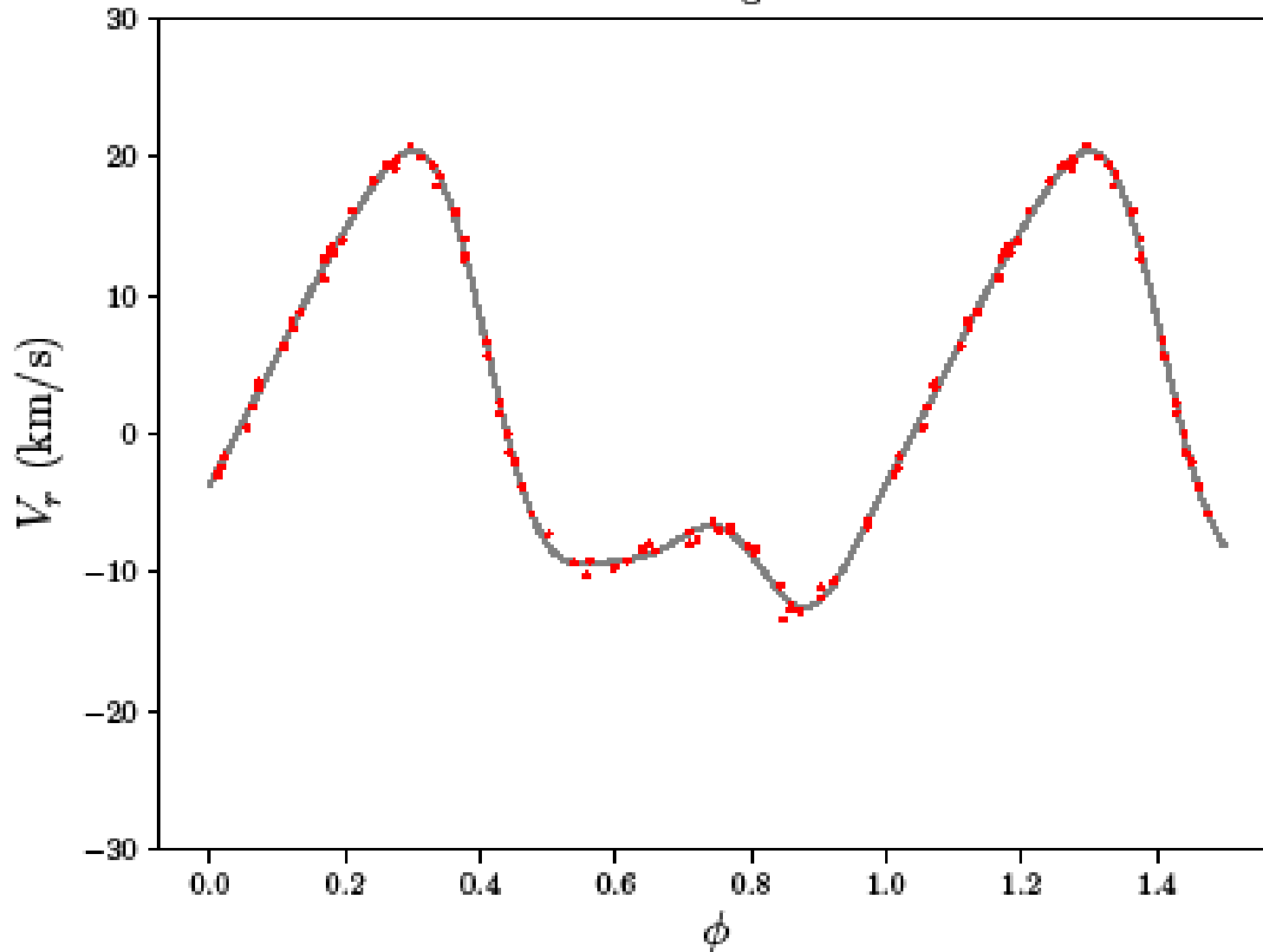
- Quality 1 (147 stars) : 0.56 km/s
- Quality 2 (71 stars) : 1.28 km/s
- All (218 stars) : 0.72 km/s

## comparison with Storm et al. (2011)

Number of stars : 76  $\rightarrow$  218

Median  $\sigma(\phi_{21})$  : 0.16  $\rightarrow$  0.04 / 0.02

YZ Sgr



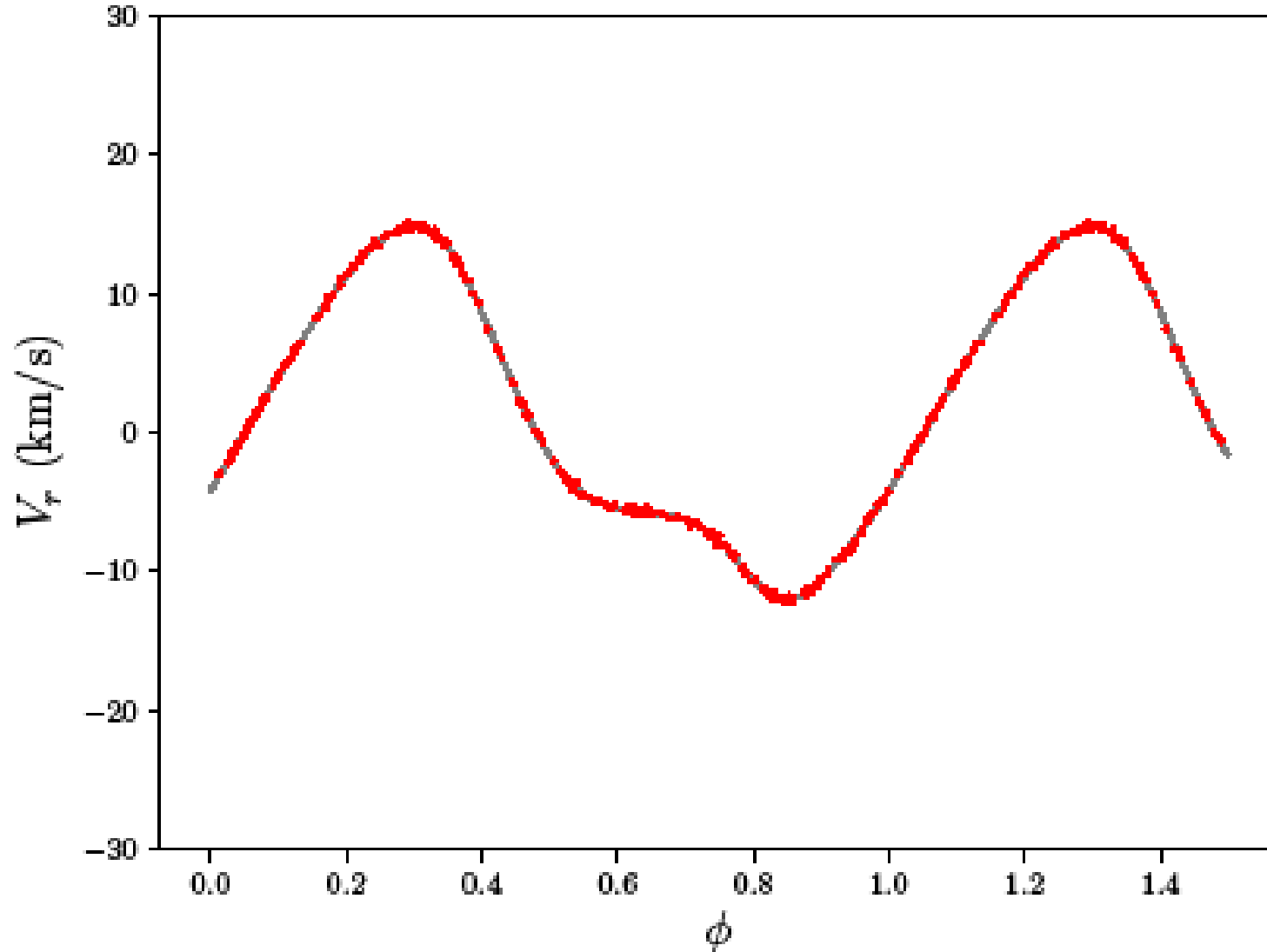
**$P = 9.55$  d**

**$N = 76$**

**$\sigma = 0.58$  km/s**

**$\sigma(\varphi_{21}) = 0.024$**

dzeta Gem

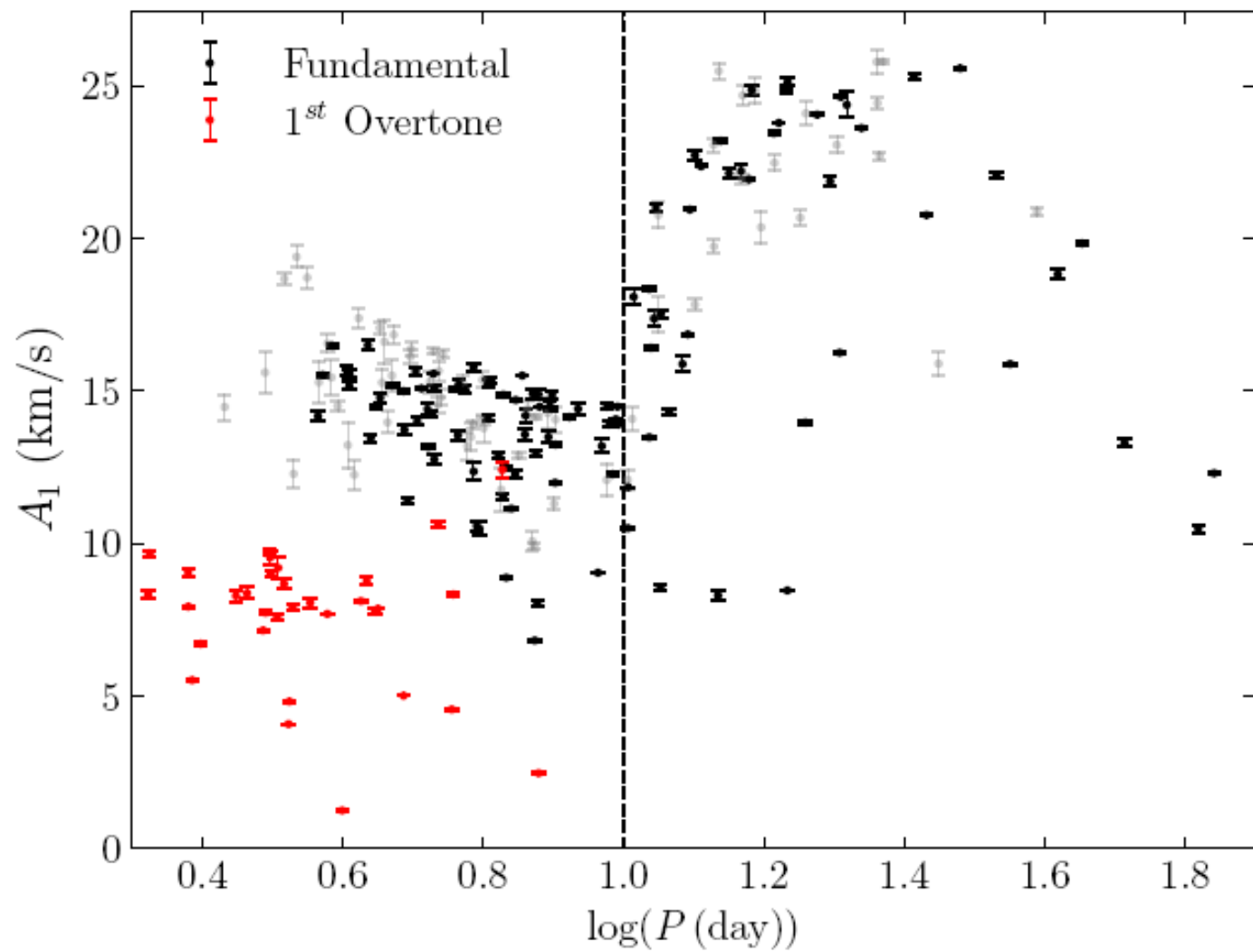


**$P = 10.15$  d**

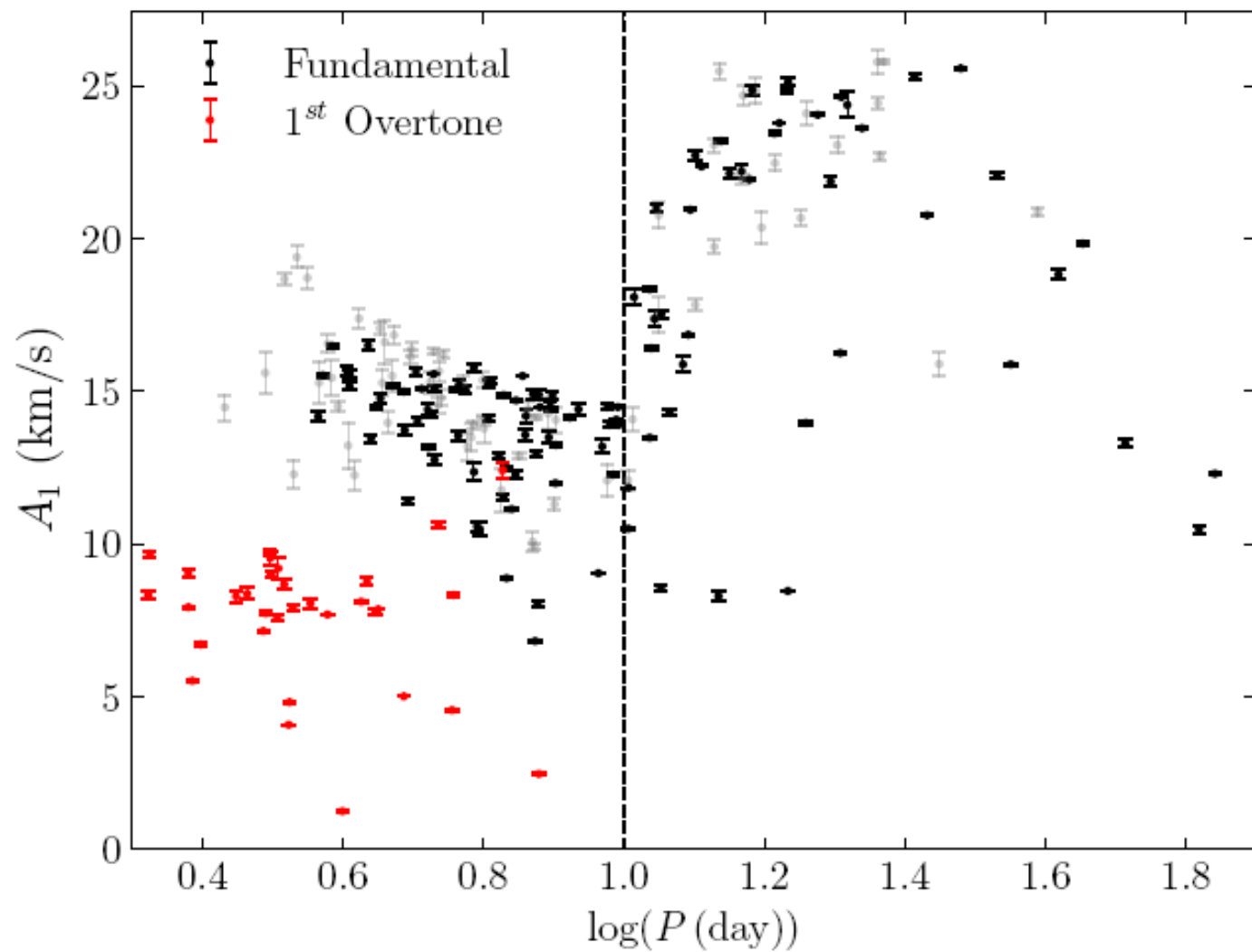
**$N = 312$**

**$\sigma = 0.15$  km/s**

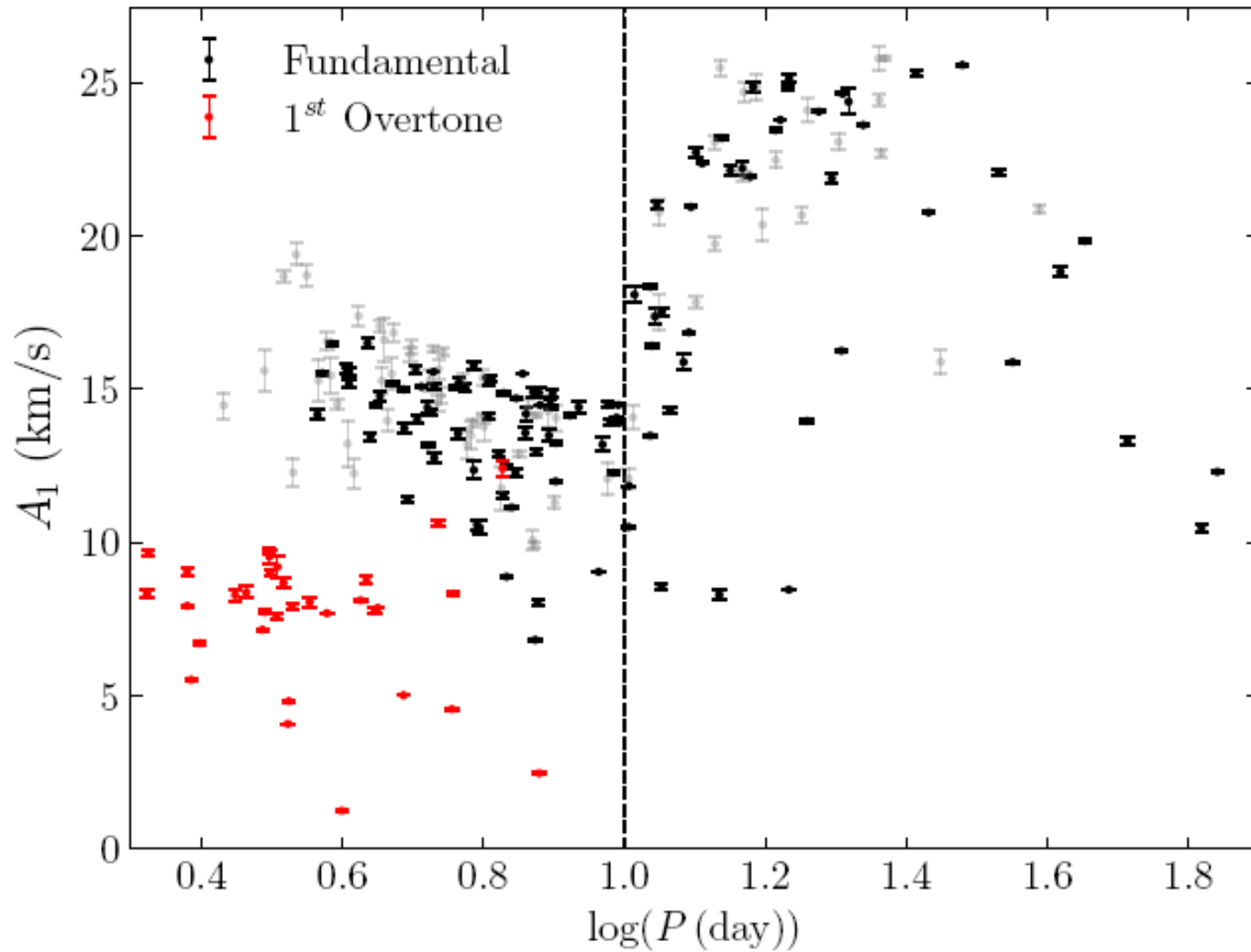
**$\sigma(\varphi_{21}) = 0.005$**





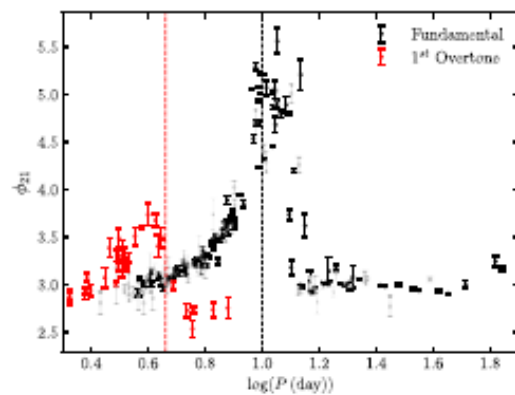


**Amplitudes of FU  
and FO Cepheids  
overlap**

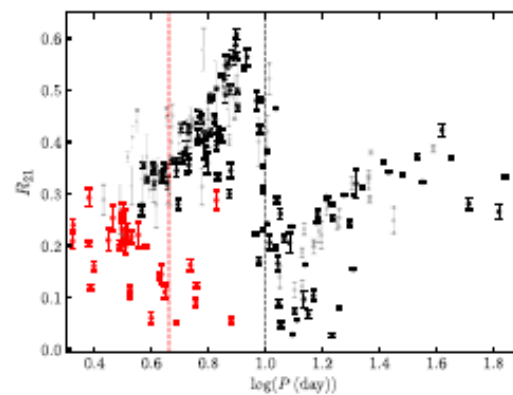


**Amplitudes of FU  
and FO Cepheids  
overlap**

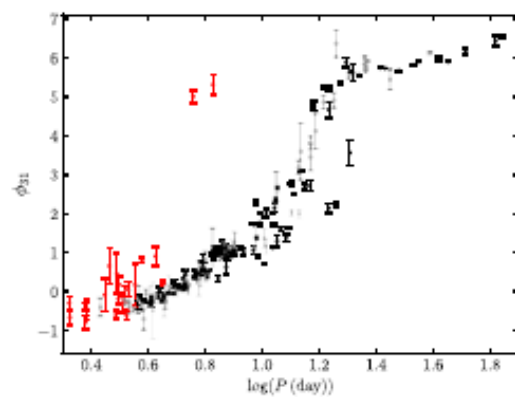
**Amplitude does  
not discriminate  
the pulsation mode**



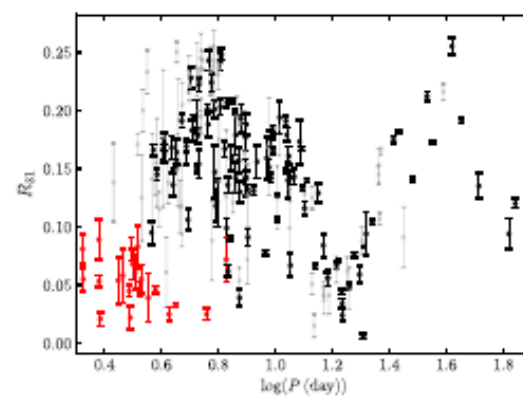
(a)



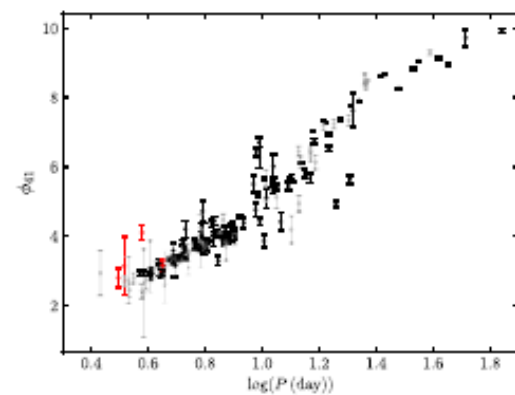
(b)



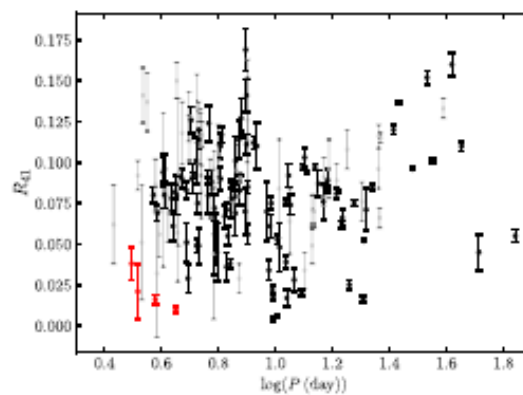
(c)



(d)



(e)



(f)

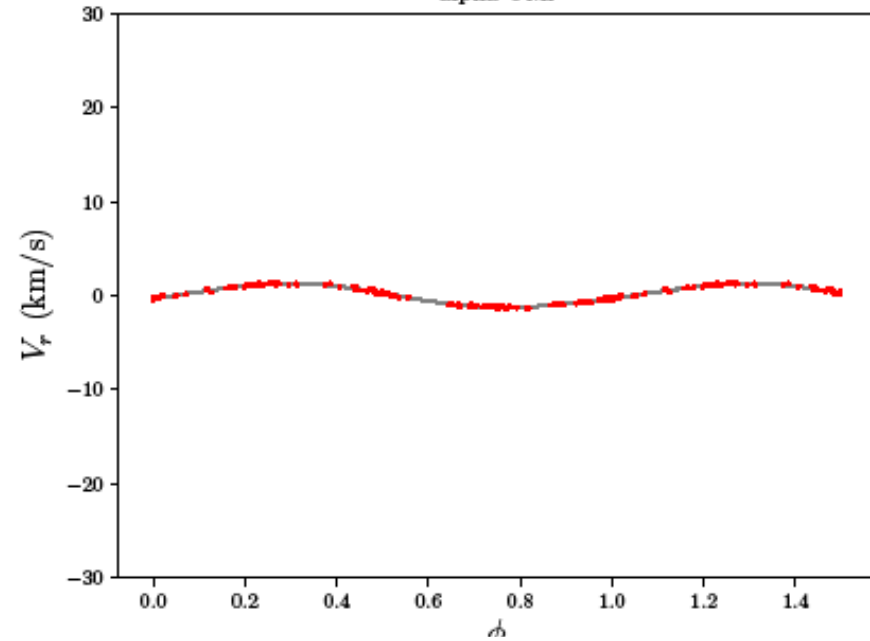
## Main results

- **catalog of Fourier parameters (with estimated errors) for radial velocity curves of 218 single-mode Classical Cepheids**
- **atlas of Classical Cepheid velocity curves**
- **velocity Fourier phases  $\varphi_{21} - \varphi_{71}$  display tight progression with pulsation period**
- **velocity Fourier phase  $\varphi_{21}$  allows mode identification for  $P > 5$  d**

## By-products („side effects”)

- **mode identification in  $\alpha$  UMi (Polaris)**

alpha UMi



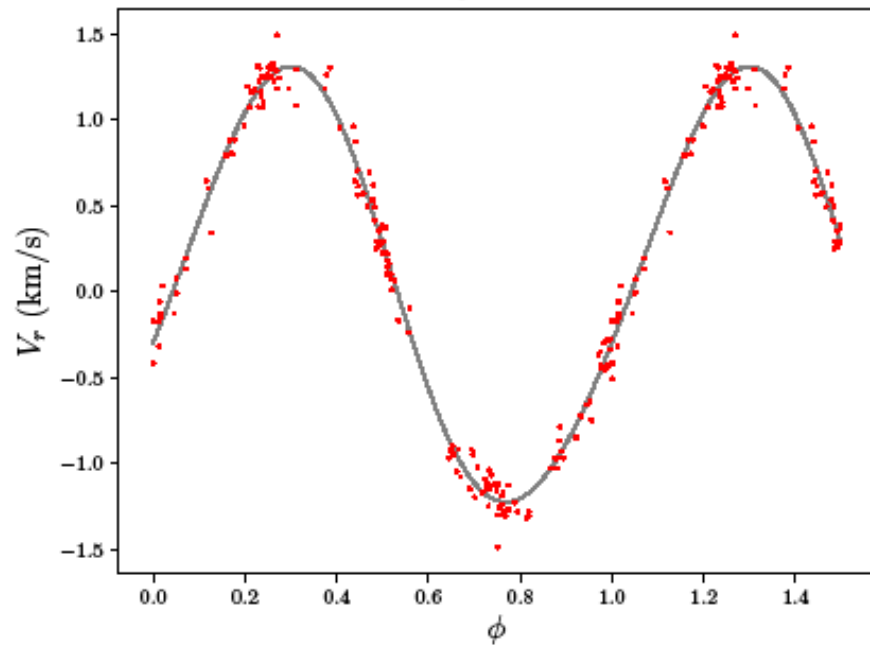
$$P = 3.97d$$

$$N = 167$$

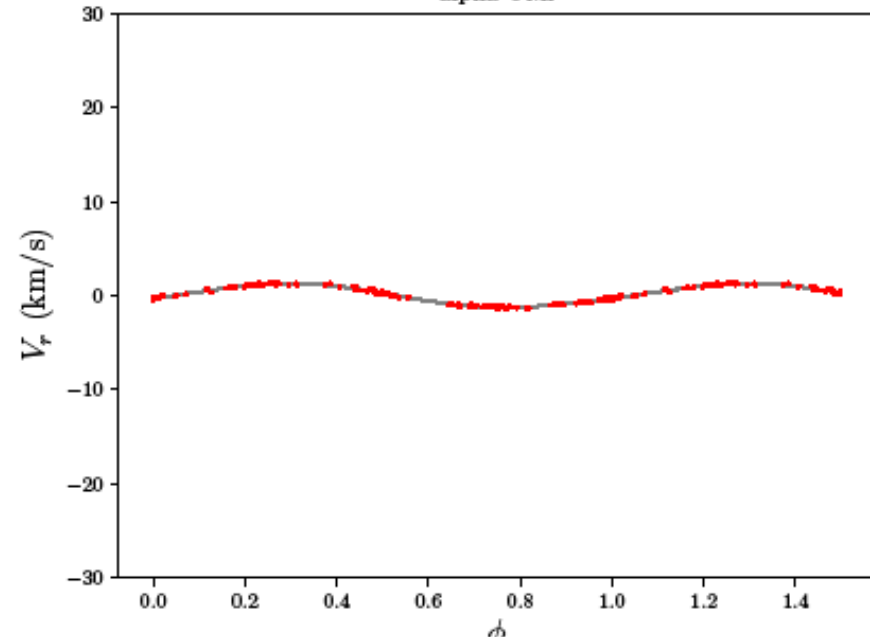
$$\sigma = 0.09\text{km/s}$$

$$\varphi_{21} = 3.736 \pm 0.113$$

alpha UMi



alpha UMi



$$P = 3.97\text{d}$$

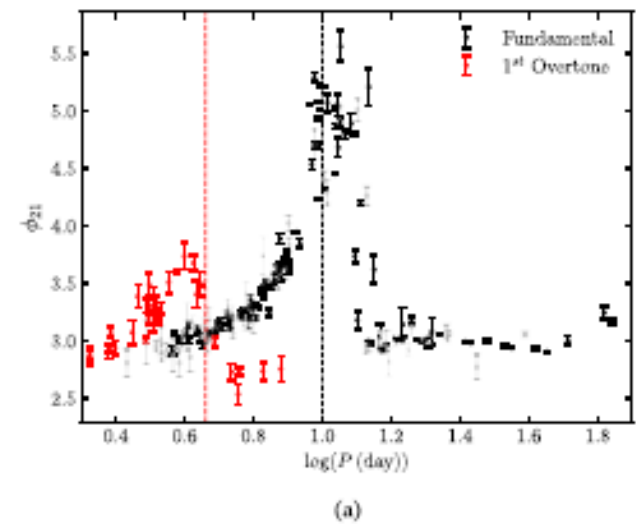
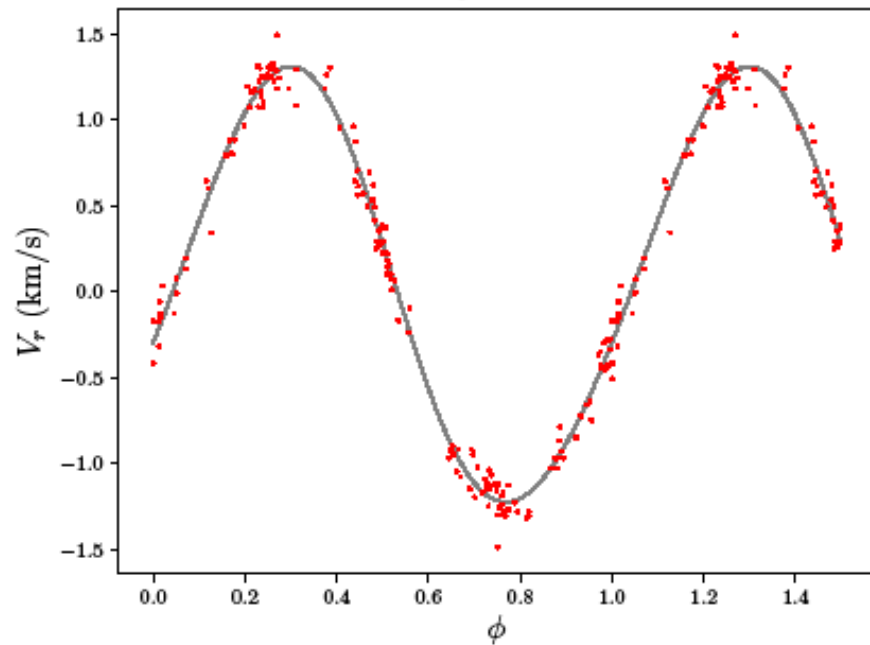
$$N = 167$$

$$\sigma = 0.09\text{km/s}$$

$$\phi_{21} = 3.736 \pm 0.113$$

**this is overtone pulsator !**

alpha UMi



## By-products

- **mode identification in  $\alpha$  UMi (Polaris)**
- **new overtone Cepheid : V495 Cyg (P = 6.72 d)**
- **confirmation of two overtone Cepheids :  
X Lac (P=5.44 d) and GH Car (P=5.73 d)**

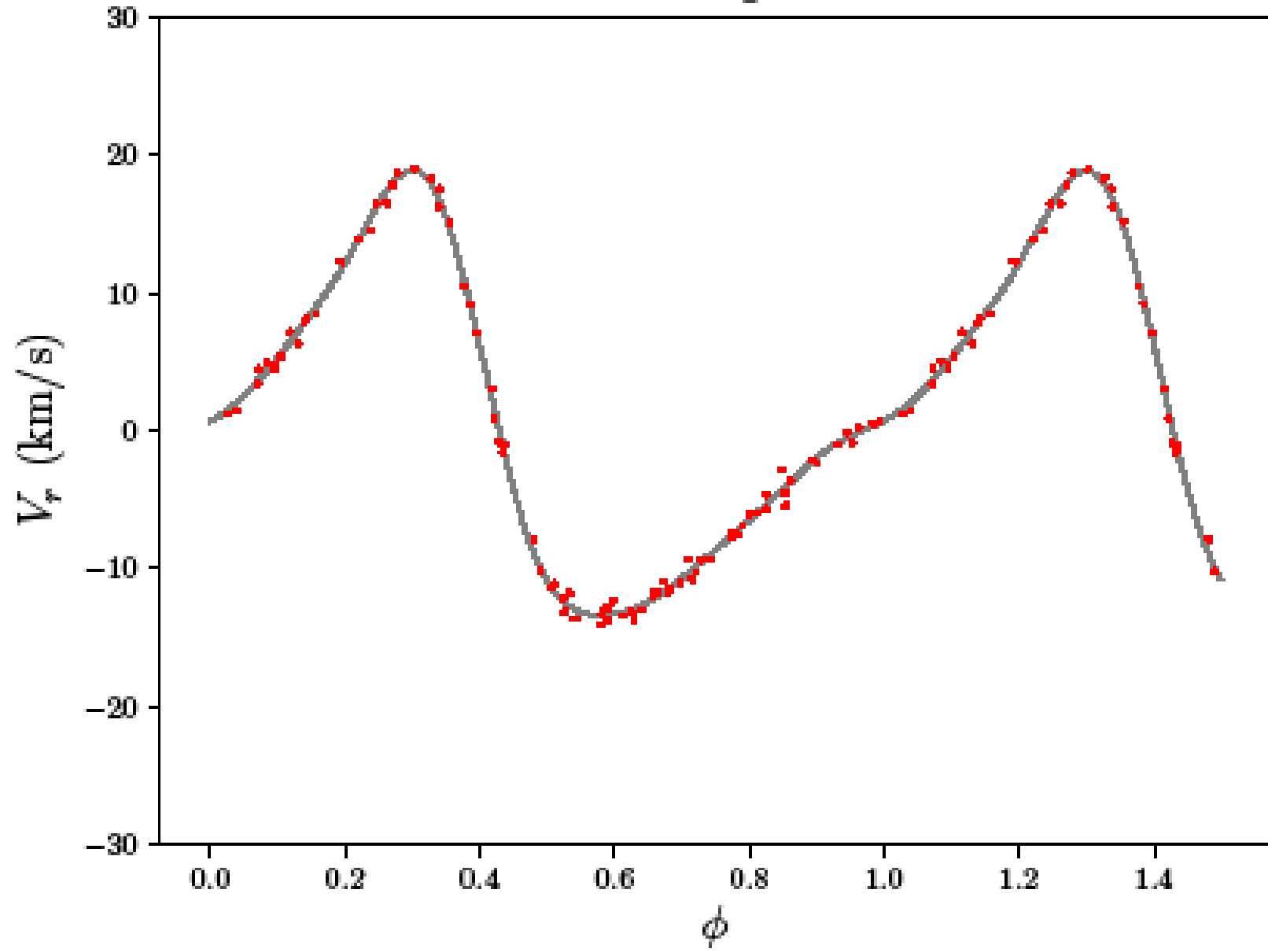


## By-products

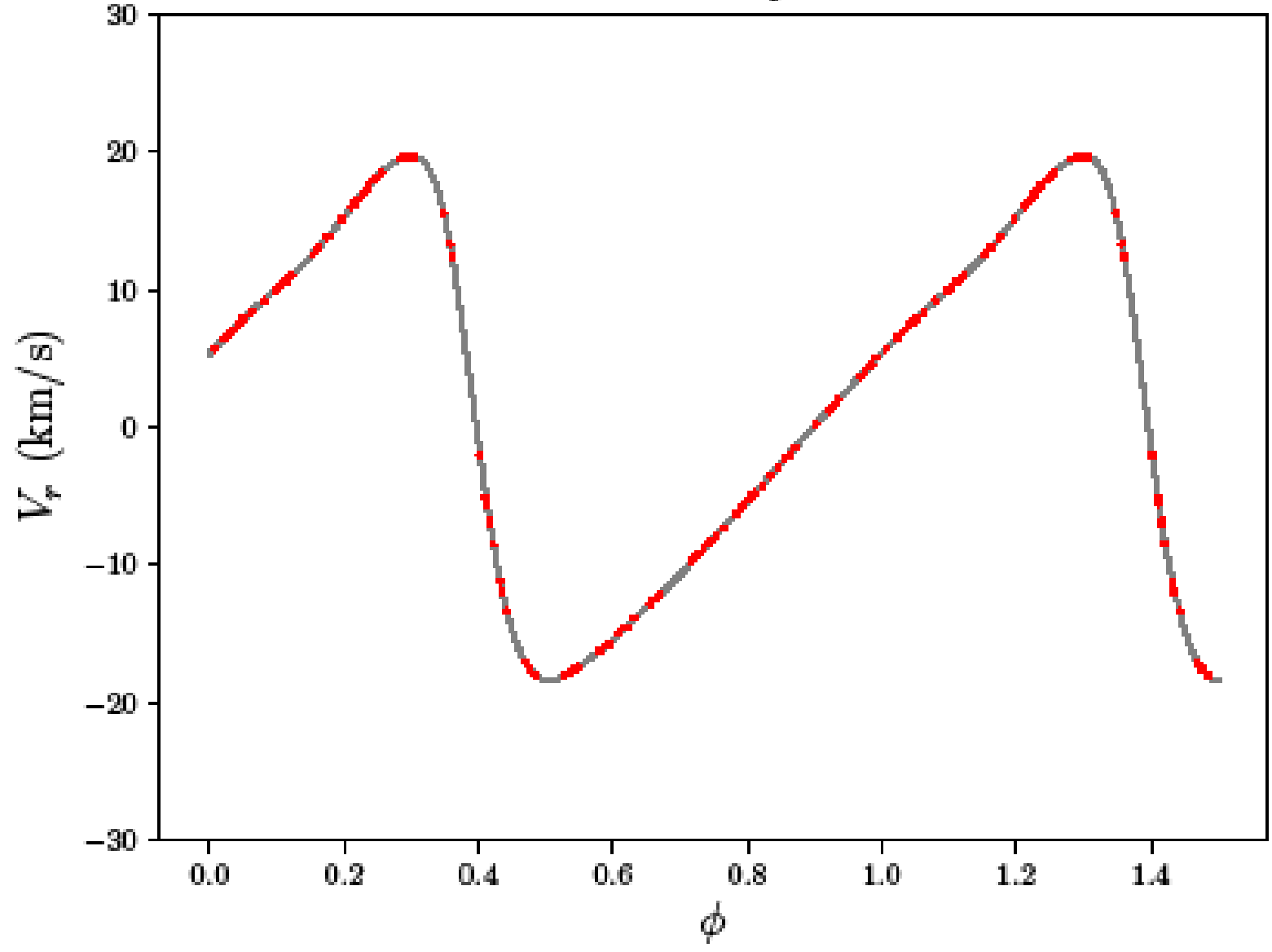
- **mode identification in  $\alpha$  UMi (Polaris)**
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X Lac (P=5.44 d) and GH Car (P=5.73 d)**
- **revised orbital period of XX Cen : 924 d  $\rightarrow$  712 d (Shetye : 722 d)**
- **new orbits of binary Cepheids (Gorynya, in prep) :  
V916 Aql ( $P_{\text{orb}} = 2434$  d), V1344 Aql ( $P_{\text{orb}} = 1932.8$  d)**
- **new binary Cepheids : VY Per (7.0 km/s in 500 days),  
AQ Pup (2.0 km/s in 800 days), QZ Nor (?) (0.5 km/s in 1000 days)**

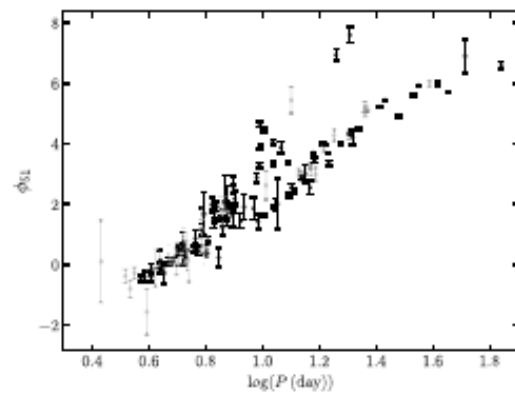


# BB Sgr

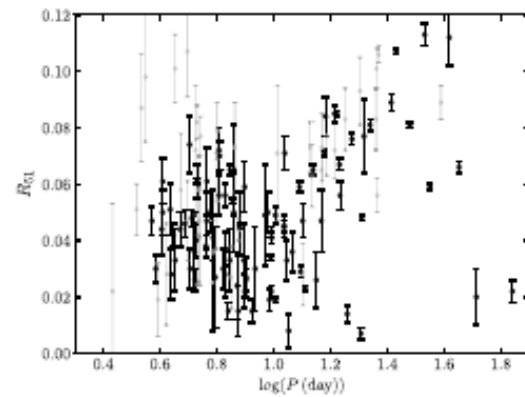


delta Cep

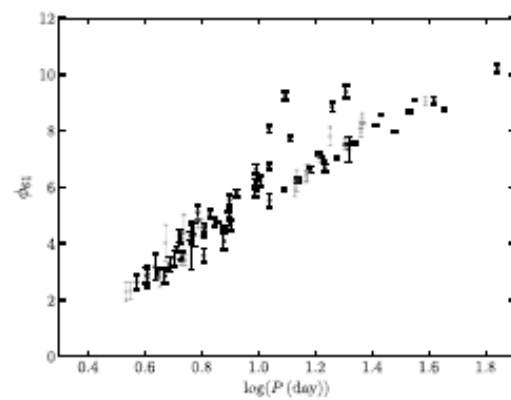




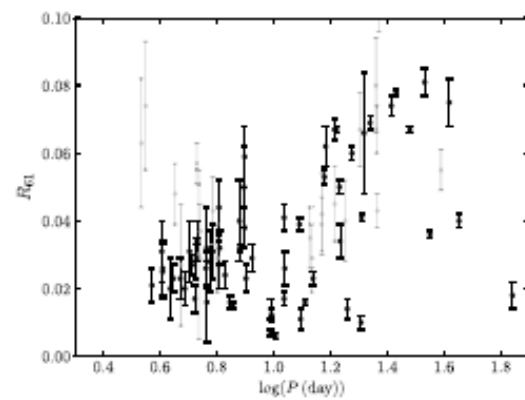
(a)



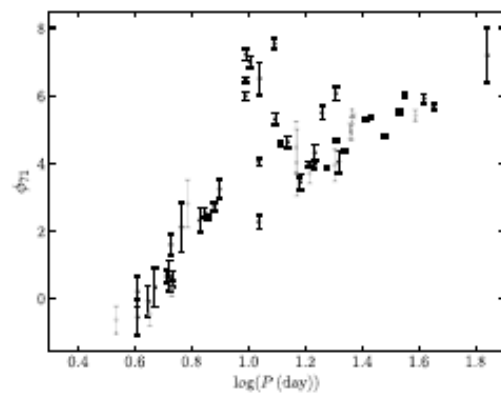
(b)



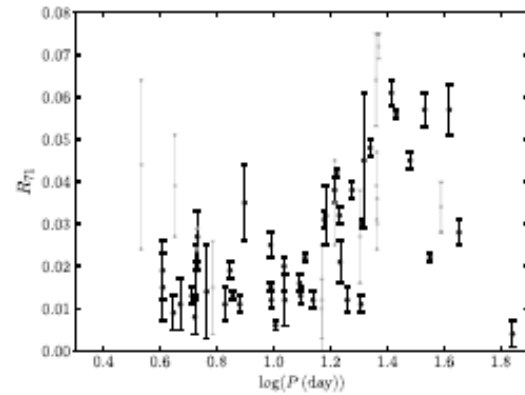
(c)



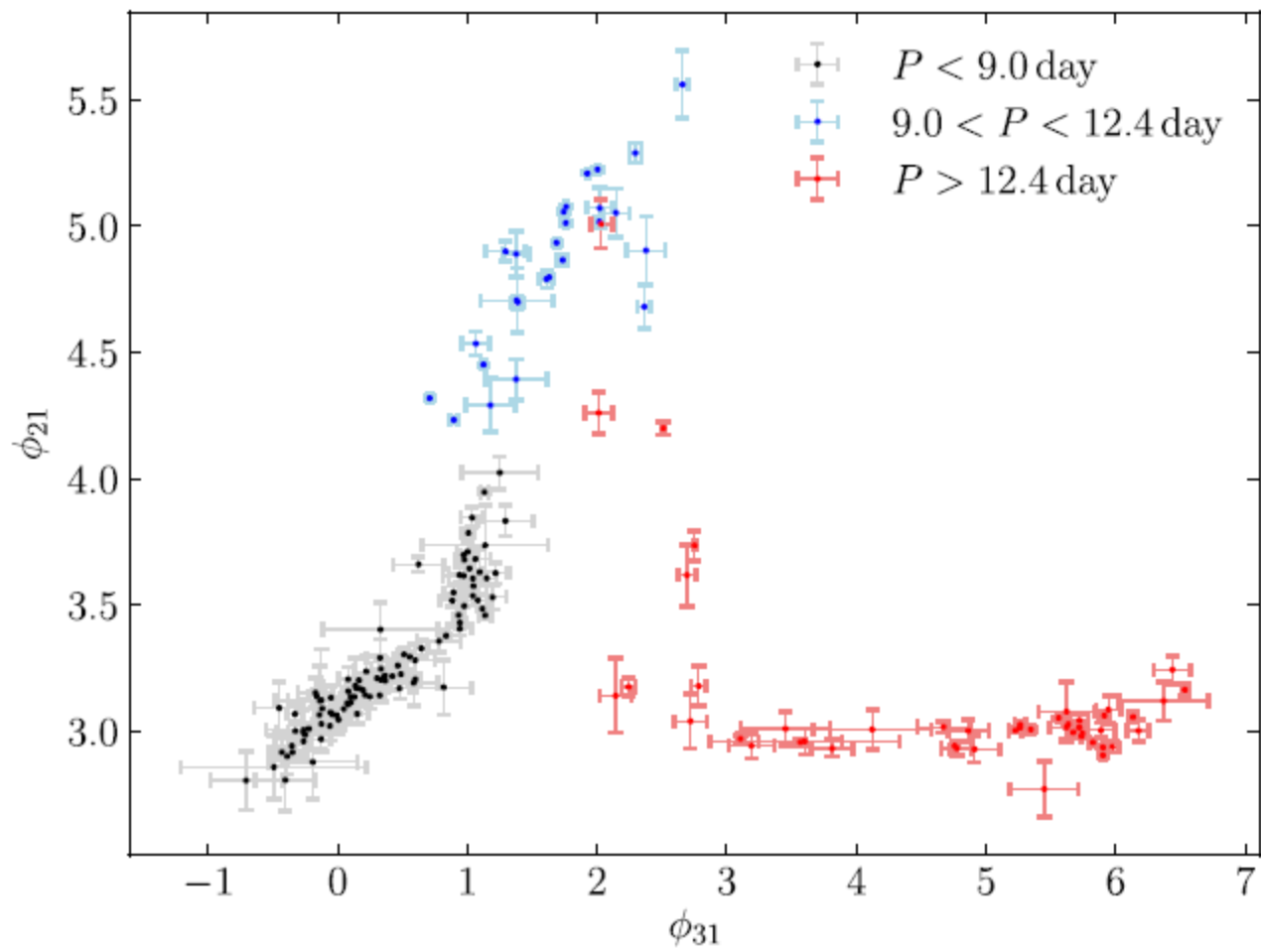
(d)

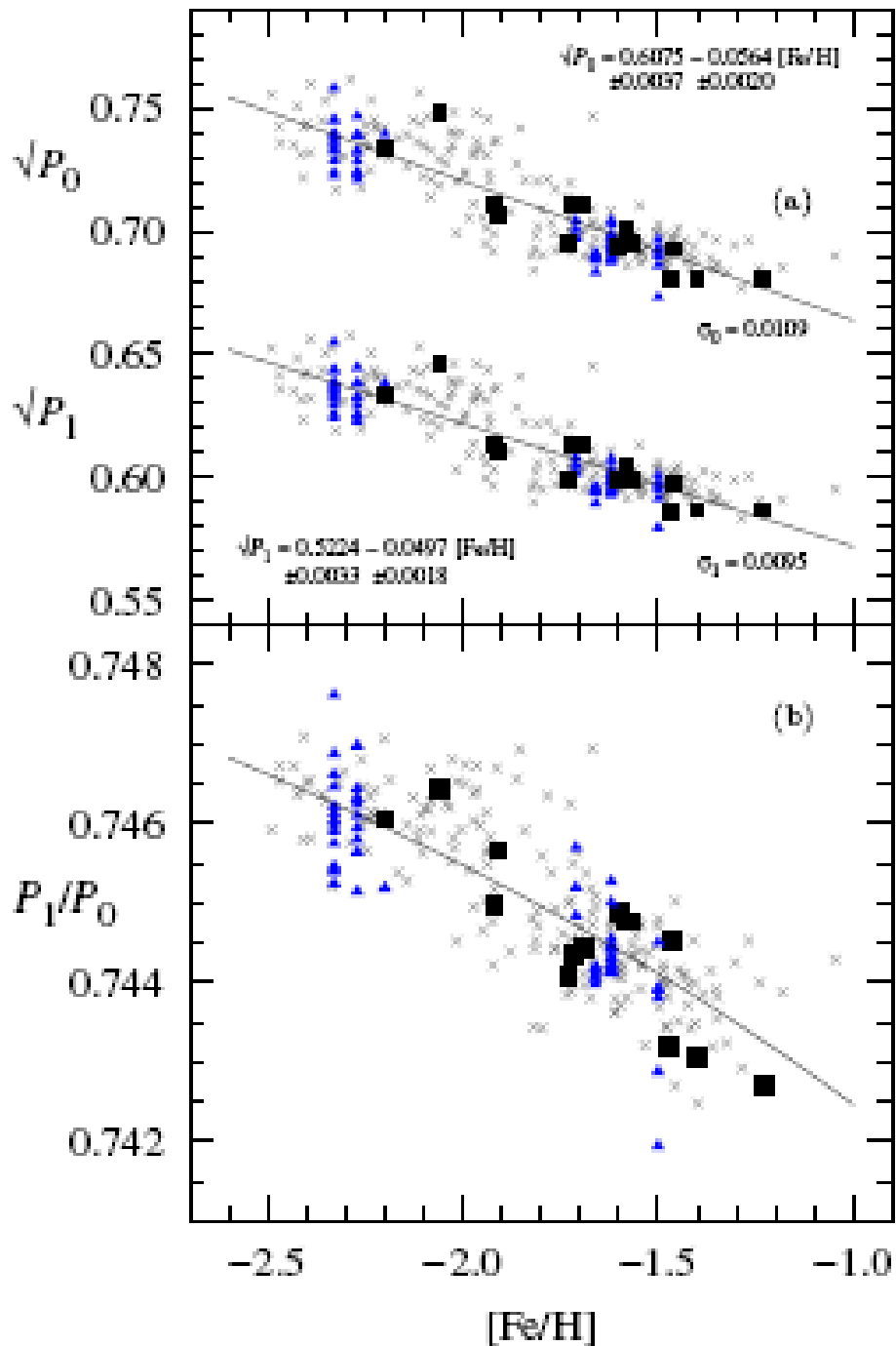


(e)



(f)





$$[Fe/H] = 7.59 - 13.25 \sqrt{P_0},$$

$$\sigma = 0.17 \text{ dex}$$

$$[Fe/H] = 7.42 - 15.08 \sqrt{P_1},$$

$$\sigma = 0.17 \text{ dex}$$