Monitoring and Intraday Variabilities of BL Lacertae

Chang et al.(2024)

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Introduction

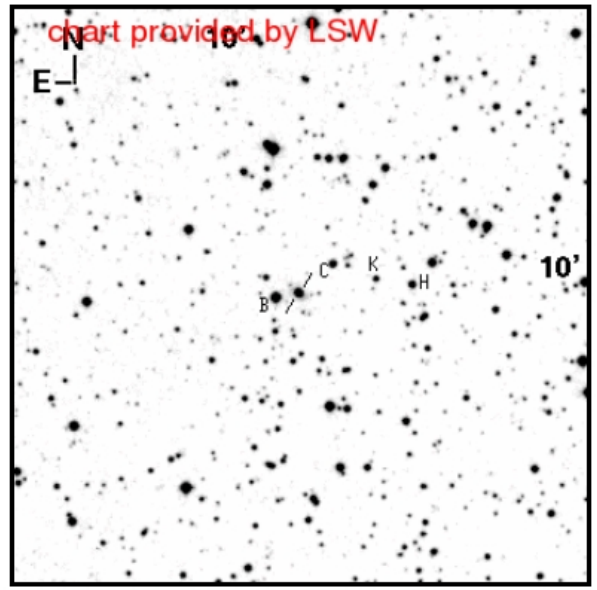
- In 2020, the author conducted observations of BL Lacertae in the g, r, and i bands. They analyzed the time scale and amplitude of BL Lac.
- It was found that the distribution of time scales exhibited a frequency-dependent behavior, with the time scale tending to shorten as the frequency increased.
- Based on the distributions of flux density and spectral index, BL Lac demonstrated a "bluer-when-brighter" behavior and exhibited some inhomogeneous features.

2200+420 (BL Lac)

Coordinates

α = 22:02:43.290 δ = +42:16:39.98 (2000)

z = 0.069



Landessternwarte Heidelberg-Königstuhl

Comparison stars

star	U	B	V	R	I
B	16.27(0.09)	14.52(0.04)	12.78(0.04)	11.93(0.05)	11.09(0.06)
C	15.53(0.06)	15.09(0.03)	14.19(0.03)	13.69(0.03)	13.23(0.04)
H	16.64(0.08)	15.68(0.03)	14.31(0.05)	13.60(0.03)	12.93(0.04)
K	16.48(0.08)	16.26(0.05)	15.44(0.03)	14.88(0.05)	14.34(0.10)

comparison stars from Smith et al., 1985, AJ 90, 1184

Field of view is 10'x10'

Magnitude Fitting of Standard Stars

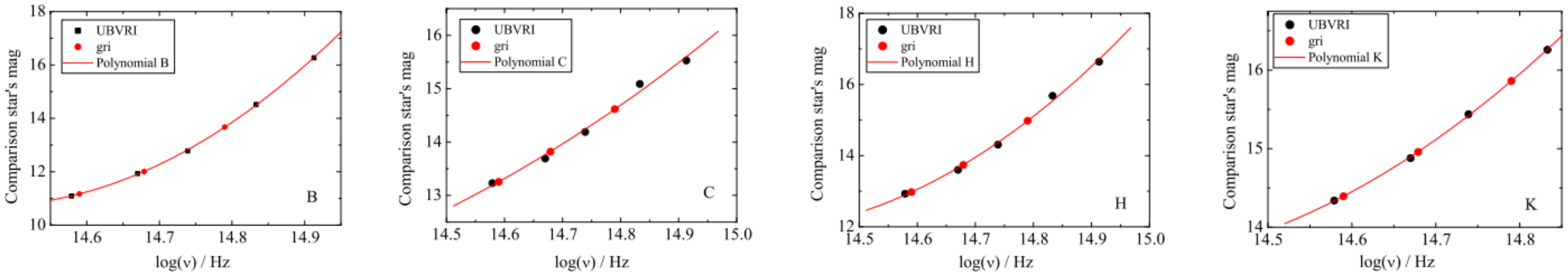
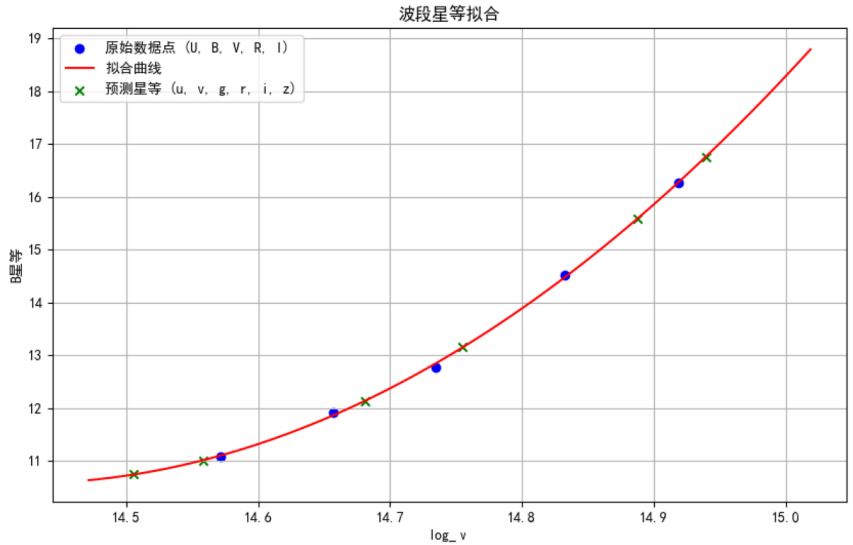
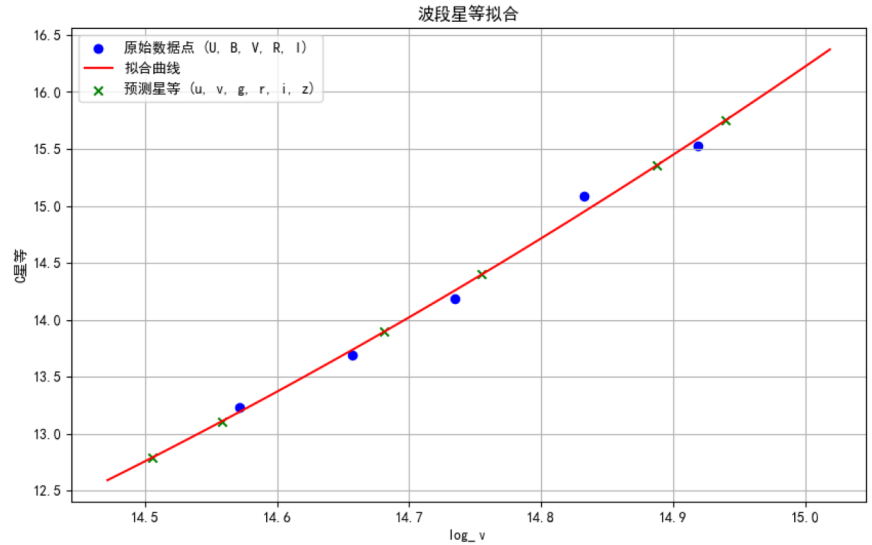


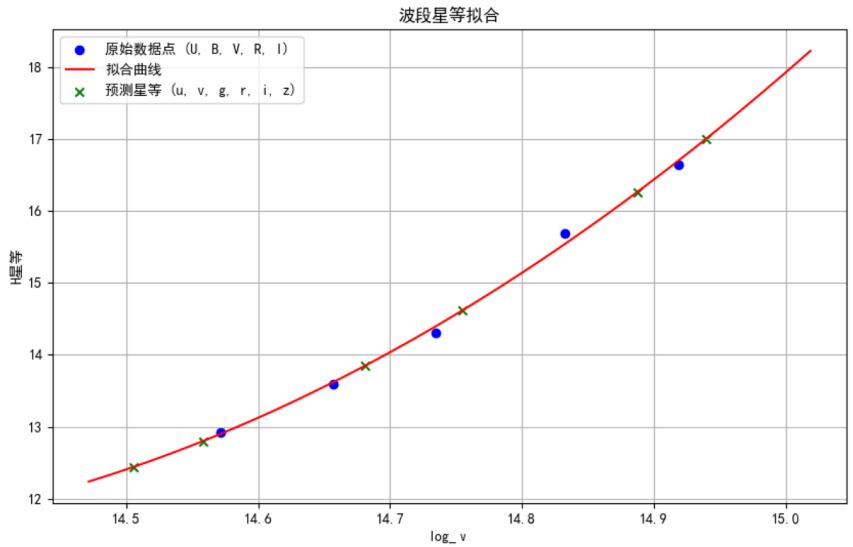
Figure 1. The *g*, *r*, and *i* fitting results of the four comparison stars. The black solid dots stand for *U*, *B*, *V*, *R*, and *I* data, the red solid dots stand for *g*, *r*, and *i* data, and the red lines stand for the least-square fitting curves.

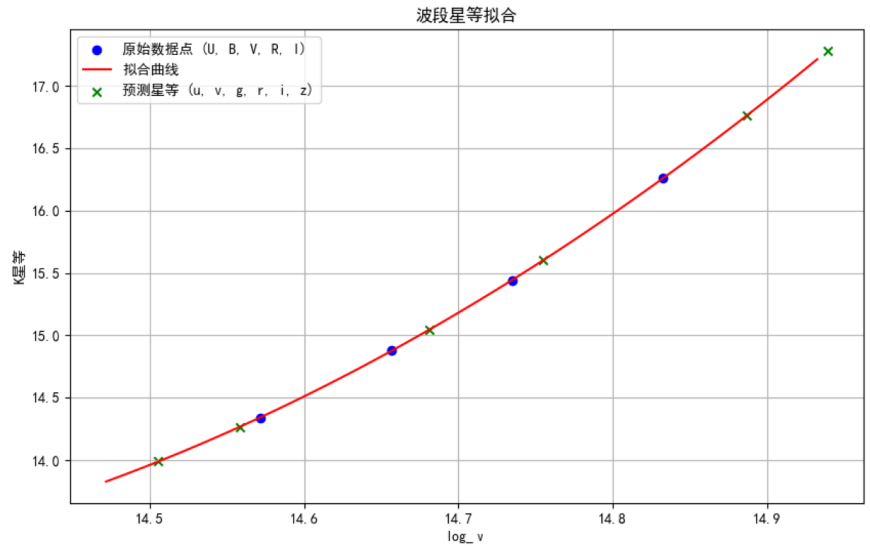
Comparison Stars of BL Lacertae (1ES 2200+420)

Comp	*U* (error) (mag)	*B* (error) (mag)	*V* (error) (mag)	*R* (error) (mag)	*I* (error) (mag)	*g* (mag)	*r* (mag)	*i* (mag)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
B	16.27 (0.09)	14.52 (0.04)	12.78 (0.04)	11.93 (0.05)	11.09 (0.06)	13.67	12.08	11.17
C	15.53 (0.06)	15.09 (0.03)	14.19 (0.03)	13.69 (0.03)	13.23 (0.04)	14.62	13.86	13.25
H	16.64 (0.08)	15.68 (0.03)	14.31 (0.05)	13.60 (0.03)	12.93 (0.04)	14.98	13.80	12.97
K	···	16.26 (0.05)	15.44 (0.03)	14.88 (0.05)	14.34 (0.10)	15.86	15.01	14.39


波段星等拟合
原始数据点（U, B, V, R, I）
拟合曲线
预测星等（u, v, g, r, i, z）
B星等
log_ v


波段星等拟合
原始数据点（U, B, V, R, I）
拟合曲线
预测星等（u, v, g, r, i, z）
Q星等
log_ v


波段星等拟合
原始数据点（U, B, V, R, I）
拟合曲线
预测星等（u, v, g, r, i, z）
H星等
log_ v

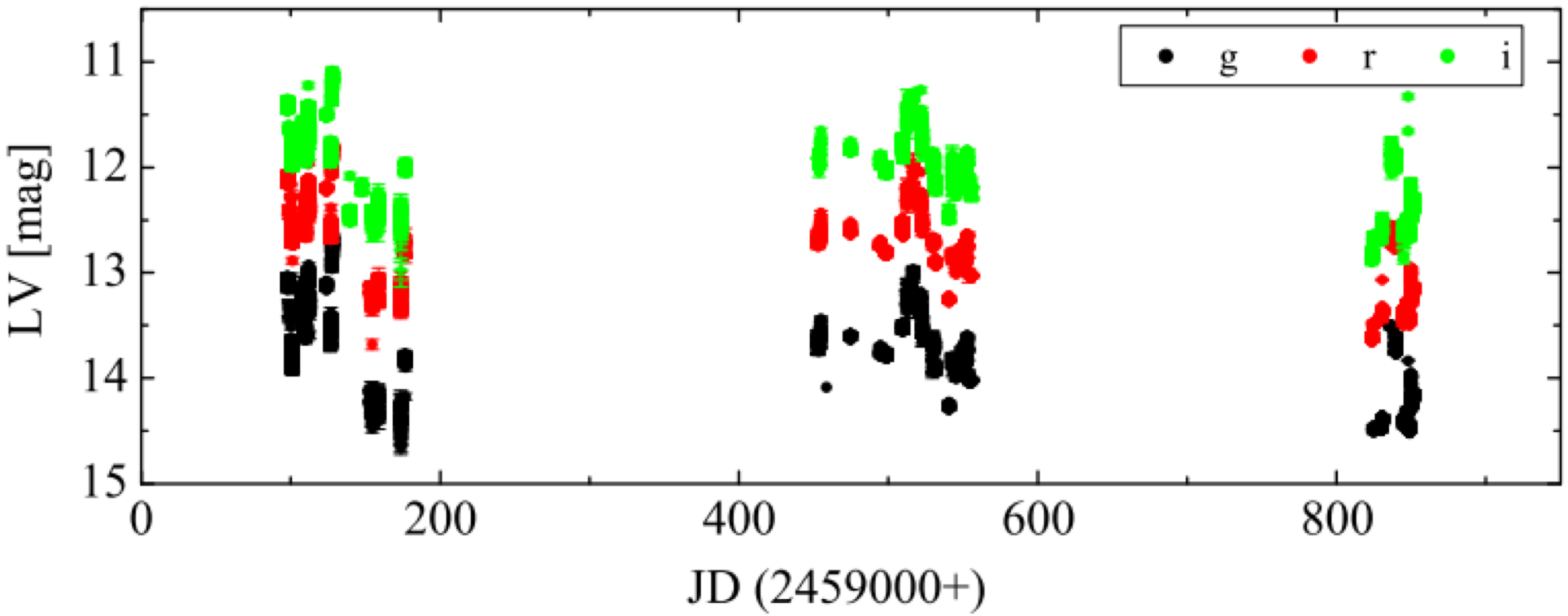

波段星等拟合
原始数据点（U, B, V, R, I）
拟合曲线
预测星等（u, v, g, r, i, z）
K星等
log_ v

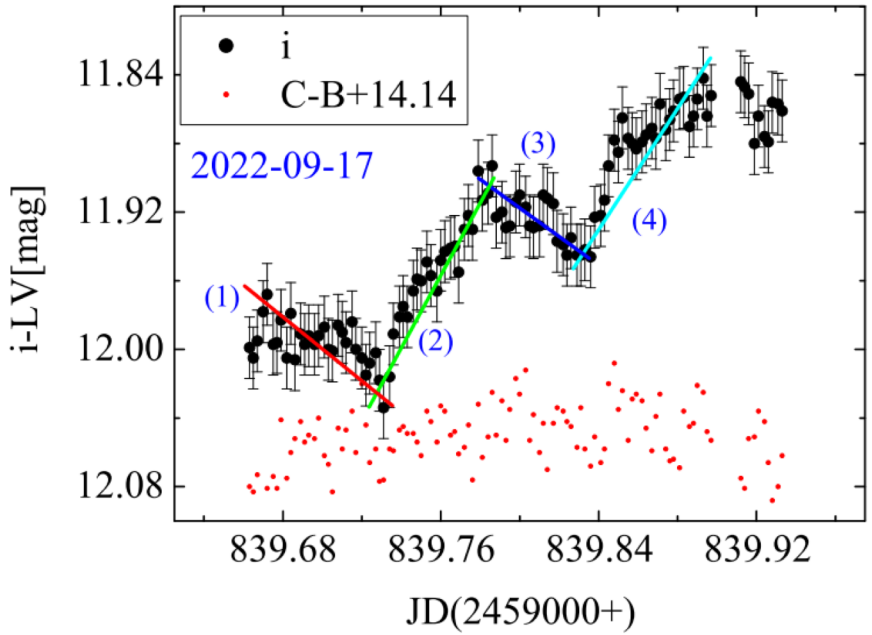
Magnitude Fitting of Standard Stars

拟合参数 B:	拟合参数 C:	拟合参数 H:	拟合参数 K:
a = 22.86	a = 2.04	a = 9.63	a = 6.08
b = -659.34	b = -53.35	b = -273.09	b = -171.72
c = 4764.24	c = 356.75	c = 1947.31	c = 1223.59
u波段星等: 16.75	u波段星等: 15.74	u波段星等: 16.99	u波段星等: 17.28
v波段星等: 15.58	v波段星等: 15.35	v波段星等: 16.25	v波段星等: 16.76
g波段星等: 13.15	g波段星等: 14.39	g波段星等: 14.61	g波段星等: 15.60
r波段星等: 12.14	r波段星等: 13.89	r波段星等: 13.84	r波段星等: 15.04
i波段星等: 11.01	i波段星等: 13.10	i波段星等: 12.80	i波段星等: 14.26
z波段星等: 10.74	z波段星等: 12.79	z波段星等: 12.44	z波段星等: 13.98

The *gri* Observations of BL Lacertae (1ES 2200+420)

g-JD (+2459000) (1)	m_g (mag) (2)	σ_g (mag) (3)	*r*-JD (+2459000) (4)	m_r (mag) (5)	σ_r (mag) (6)	*i*-JD (+2459000) (7)	m_i (mag) (8)	σ_i (mag) (9)
97.691	13.104	0.029	97.691	12.106	0.027	97.691	11.403	0.027
97.692	13.111	0.029	97.692	12.085	0.027	97.692	11.383	0.027
97.693	13.118	0.029	97.693	12.108	0.027	97.693	11.406	0.027
97.695	13.111	0.029	97.695	12.117	0.027	97.695	11.414	0.027
97.696	13.117	0.029	97.696	12.114	0.027	97.696	11.412	0.027
97.697	13.125	0.029	97.697	12.110	0.027	97.697	11.408	0.027
97.698	13.124	0.029	97.698	12.122	0.027	97.698	11.419	0.027
97.699	13.131	0.029	97.699	12.123	0.027	97.699	11.421	0.027
97.701	13.140	0.029	97.701	12.127	0.027	97.701	11.424	0.027
97.702	13.121	0.029	97.702	12.111	0.027	97.702	11.409	0.027

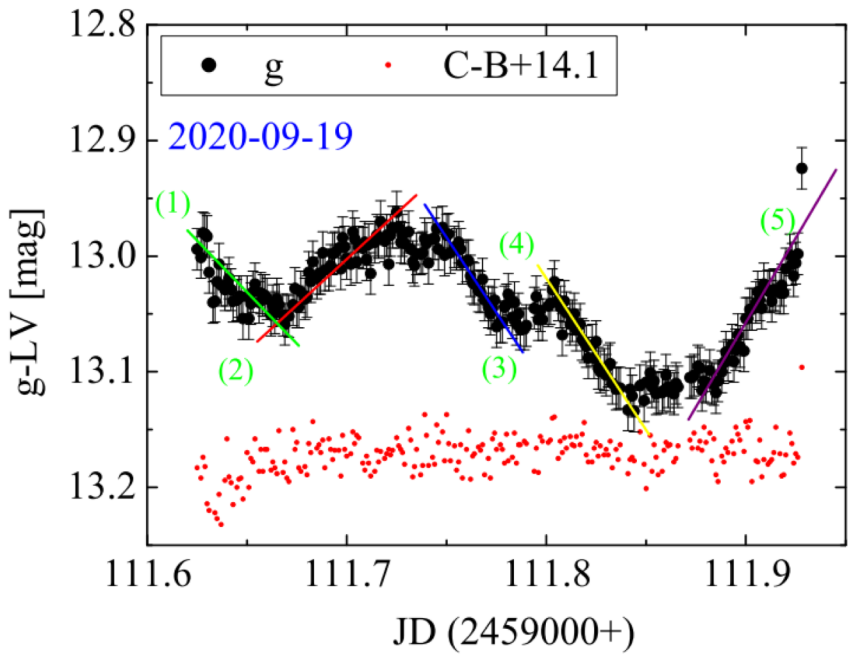


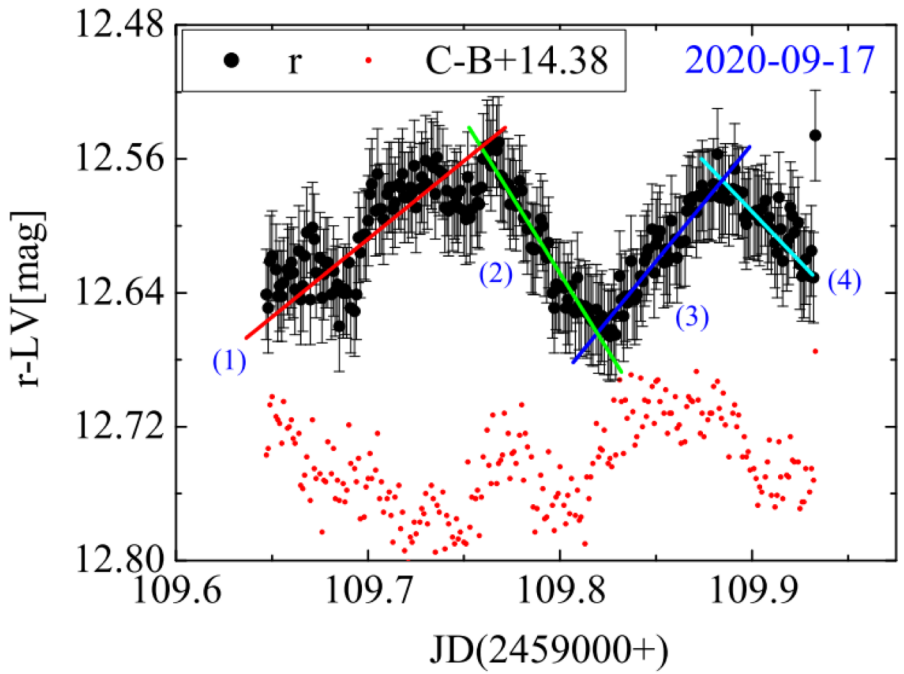


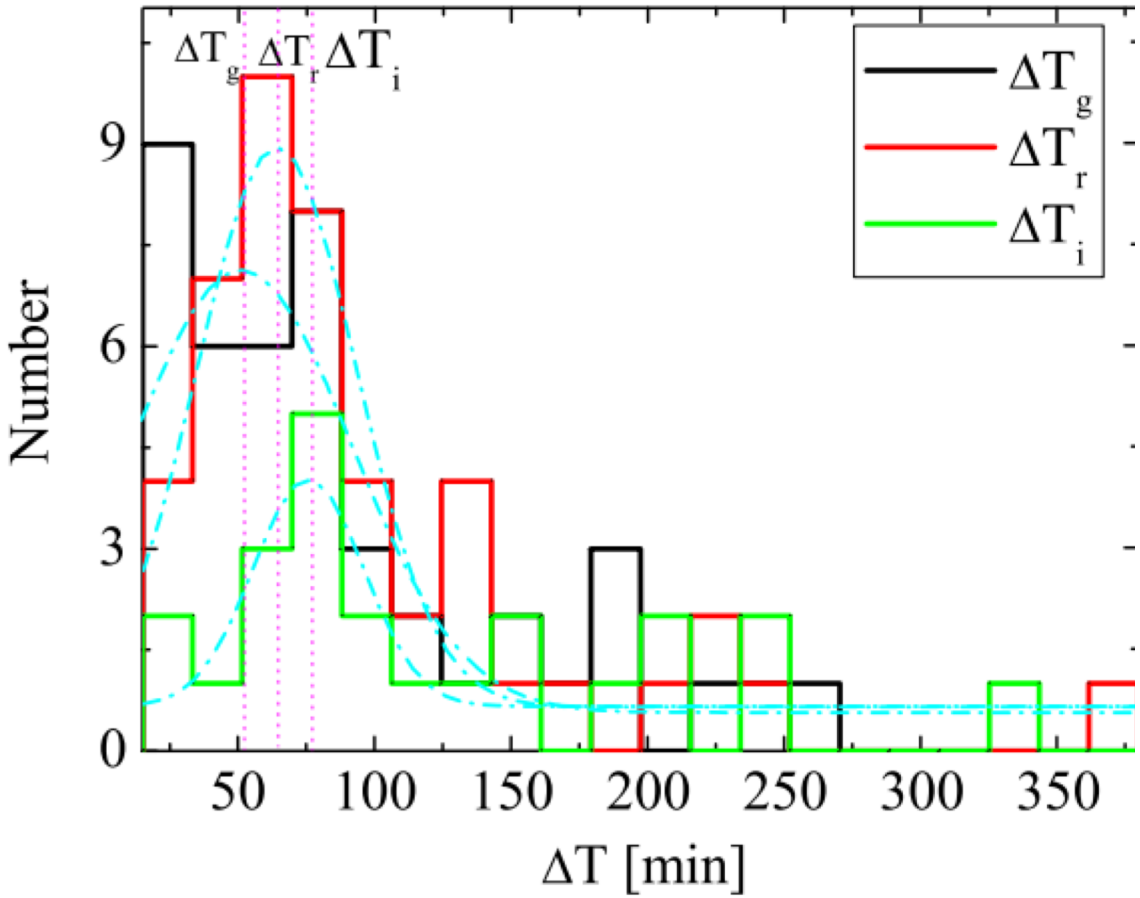
$\Delta m_g : 0.366 \pm 0.009$

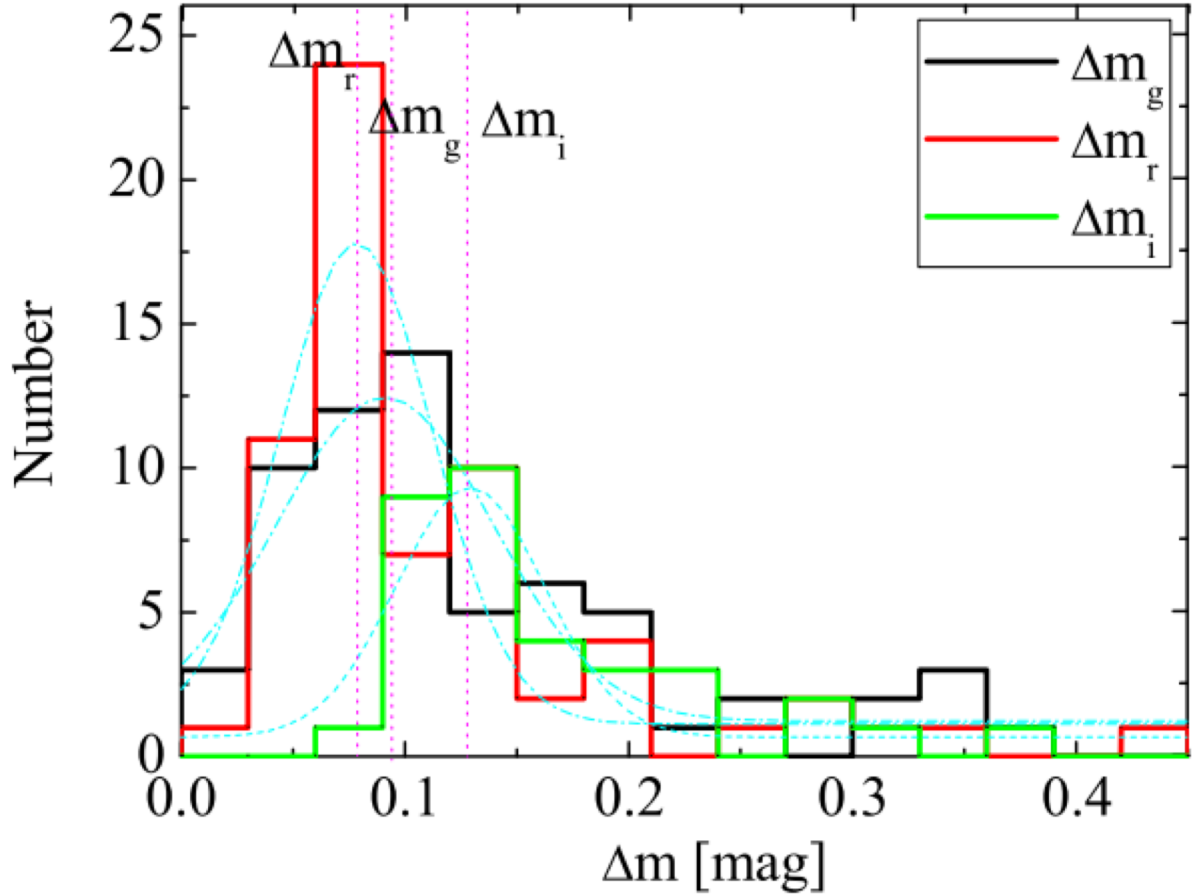
$\Delta m_r : 0.357 \pm 0.010$

$\Delta m_i : 0.222 \pm 0.041$









$\Delta T_g = 51.72 \pm 6.02$ m

$\Delta T_r = 63.95 \pm 2.61$m

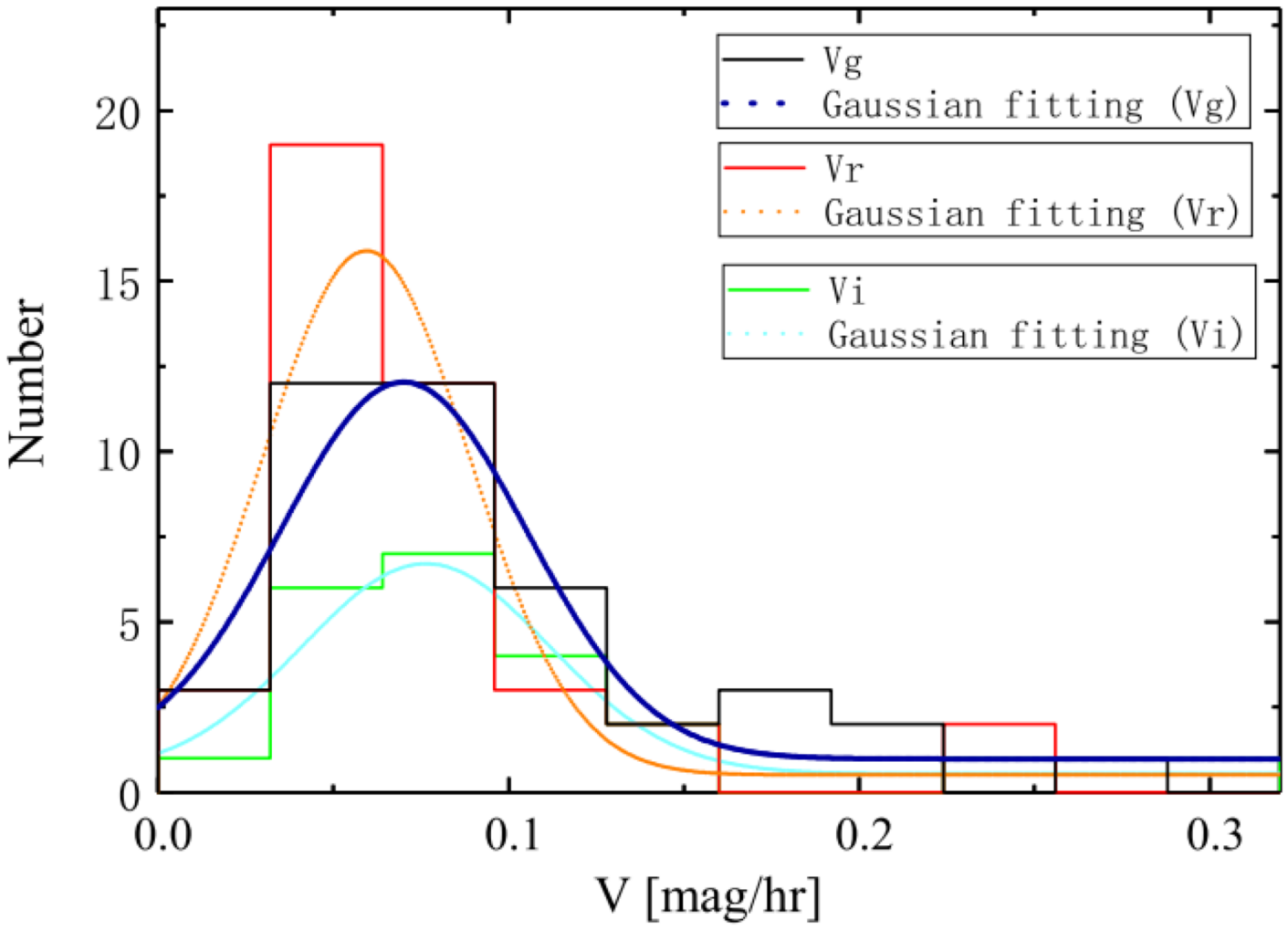
$\Delta T_i = 75.50 \pm 3.87$m

$\Delta m_g : 0.366 \pm 0.009$

$\Delta m_r : 0.357 \pm 0.010$

$\Delta m_i : 0.222 \pm 0.041$

Timescale and Amplitude Distribution



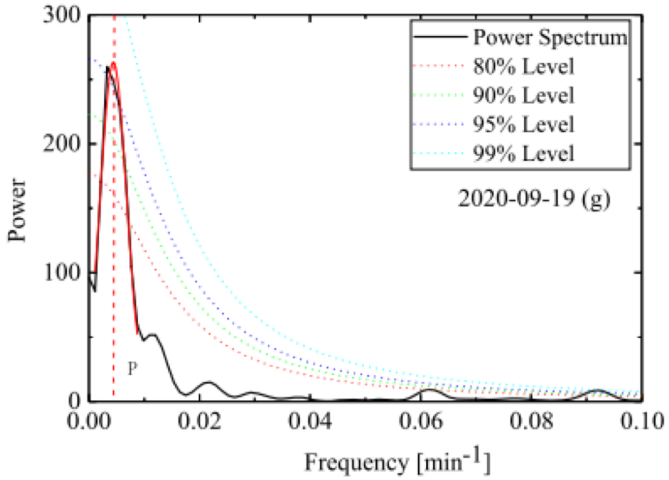
$V = \Delta m / \Delta T$

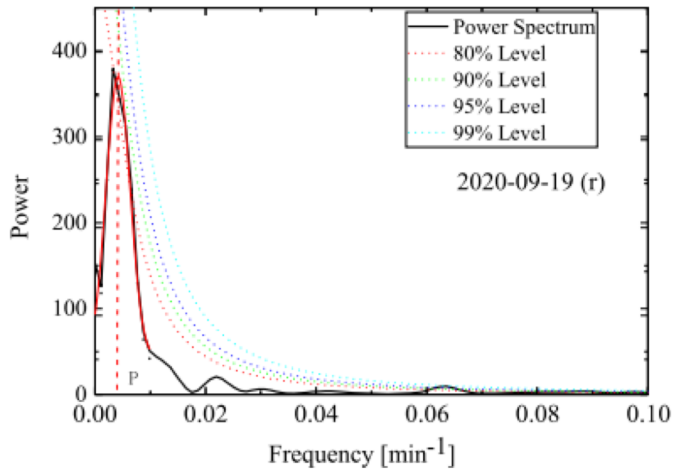
$V_g = 0.070 \pm 0.011$, $r_g = 0.78$

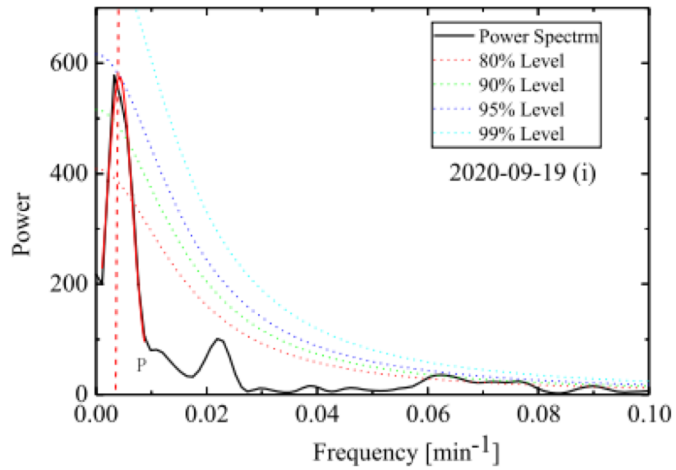
$V_r = 0.059 \pm 0.005$, $r_r = 0.72$

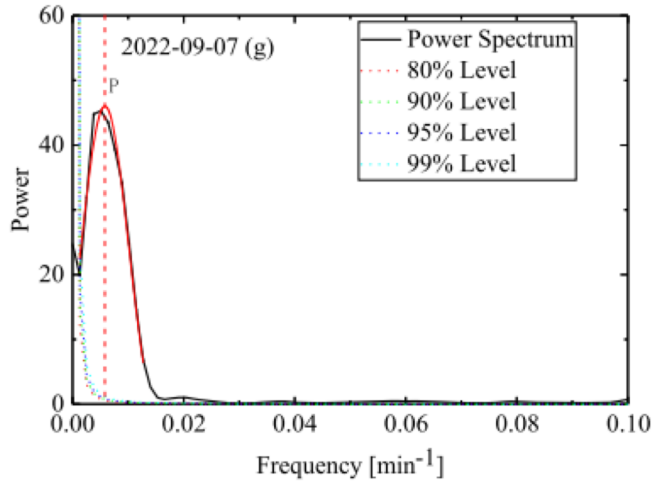
$V_i = 0.076 \pm 0.005$, $r_i = 0.78$

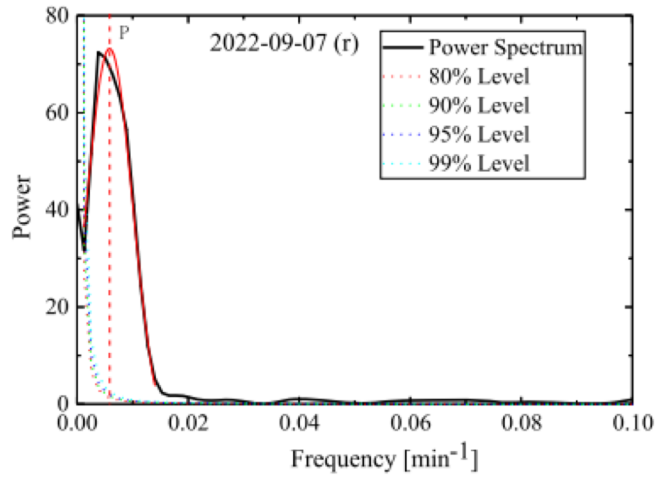
Introduction

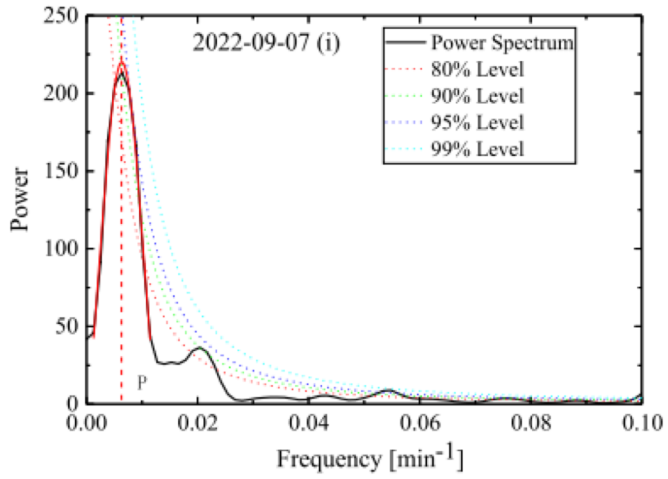


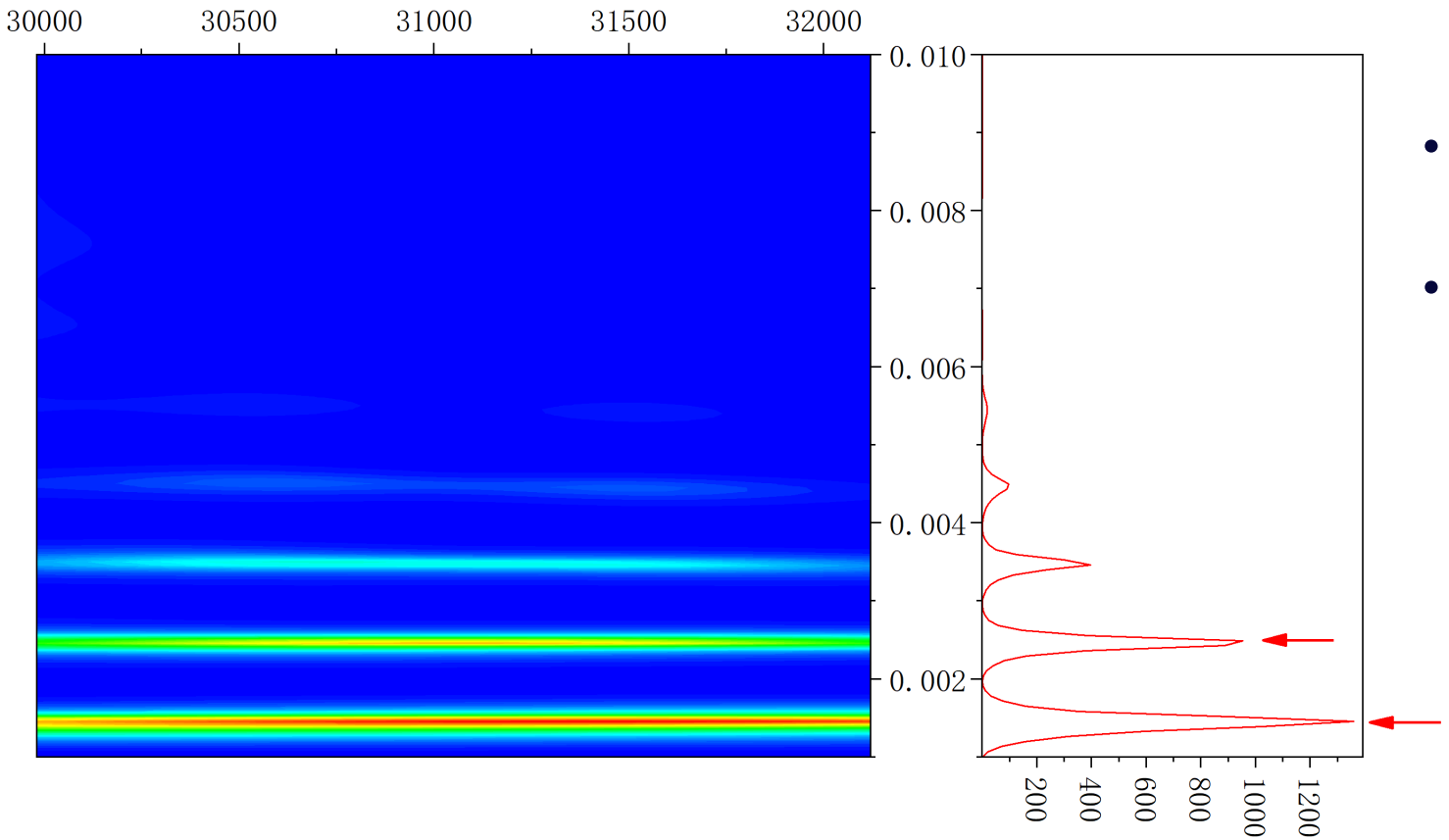






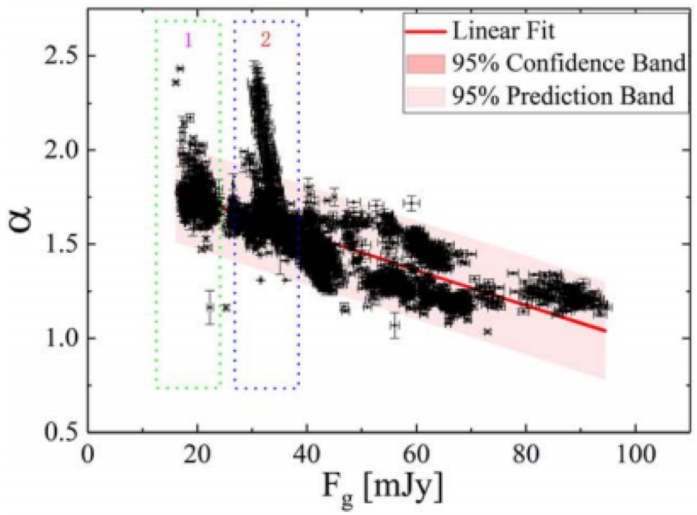


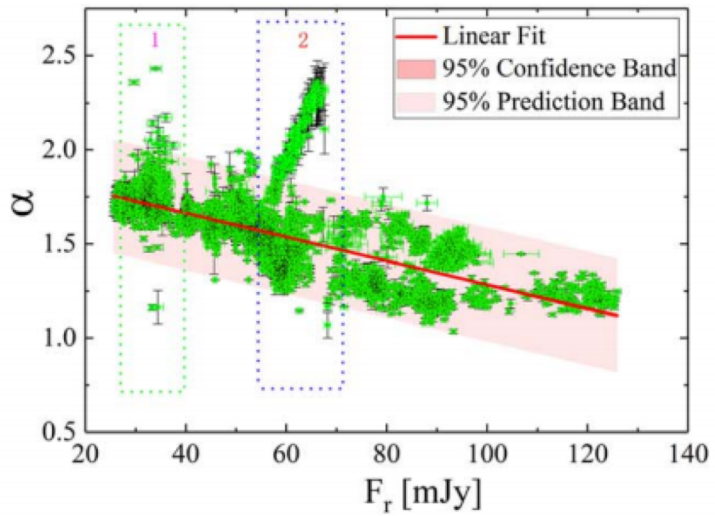


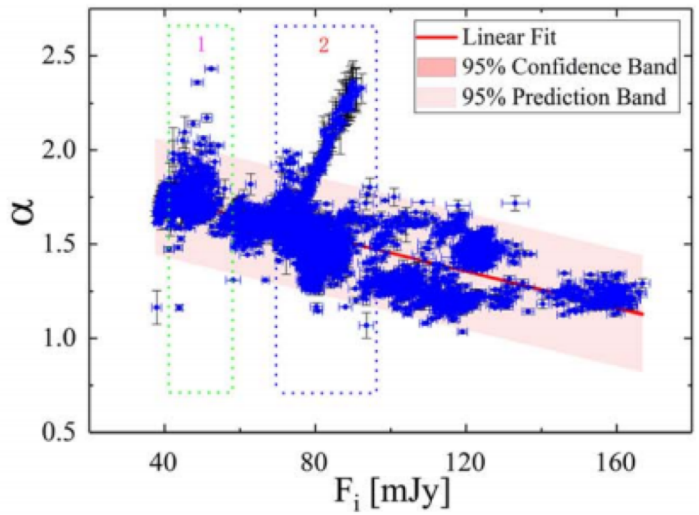


- 2024.11.16~18，the two highest peaks：10 and 16 hours.
- Jorstad et al. (2022) reported a quasi-periodic oscillation (QPO) with a period of approximately 13 hours.

Spectral Index (α) and Flux Density (F)







$$Ag = 1.086\,mag\,, \quad Ar = 0.751\,mag\,, \quad Ai = 0.558\,mag$$

$$\nu_g = 6.17 \times 10^{14}\,Hz, \quad \nu_r = 4.77 \times 10^{14}\,Hz, \quad \nu_i = 3.89 \times 10^{14}\,Hz$$

$$F_i = \lambda_i \times 10^{-0.4 \times i_{mag}} \times 10^6\ \ mJy, \quad (i = g, r, i)$$

$$\alpha_{12} = -\frac{\log\left(\frac{F_1}{F_2}\right)}{\log\left(\frac{\upsilon_1}{\upsilon_2}\right)}$$

$r_g = -0.77$

$r_r = -0.68$

$r_i = -0.66$

Thanks!