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CORRELATION BETWEEN QUADRUPLE GLK PARAMETERS

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Abstract

The purpose of studying GLKs is to study them, so that humanity can understand dark matter, dark matter, matter around black holes, their properties. To find correlations between parameters and derive equations connecting them. The connection between the components of GraL J024848.7+191331, brightness curves, microlensing.

Introduction

This work presents abstract images and lensing object parameters for a number of gravitationally lensed quasars (GLQs), such as GraL J024848.7+191331. These include recently discovered objects, such as the lensed quasar described in this example, which was discovered in late 2020. Currently, new lensed quasars are being discovered continuously within the framework of the GAIA space project. It is known that gravitational lensing is considered a unique and valuable tool for solving a number of cosmological problems. These issues include the value of the Hubble constant at different distances, the properties of dark matter, the properties of matter around the horizon of supermassive black holes, etc. Therefore, each GLK requires separate study.

GLK GraL J024848.7+191331 is a newly discovered quasar, which has been identified as consisting of four abstract images. It was identified as a quasar in the work and was therefore considered a candidate for lensed quasars. The maximum angular distance between images turned out to be 1.7''. The spectra of the images also confirmed that this object was indeed a GLK, and it was classified as a broad absorption line quasar. Its spectra showed strong OVI emission lines ($\lambda = 1032.0$ and $\lambda = 1037.6$) and a system of absorption lines in the region at $z = 1.037$. The latter may belong to a lensing object.

Observations of this object were conducted on the AZT-22 telescope at the Maidanak Observatory with an R filter in August-October 2021 (Figure 1). As a result, we obtained 26 observation points.

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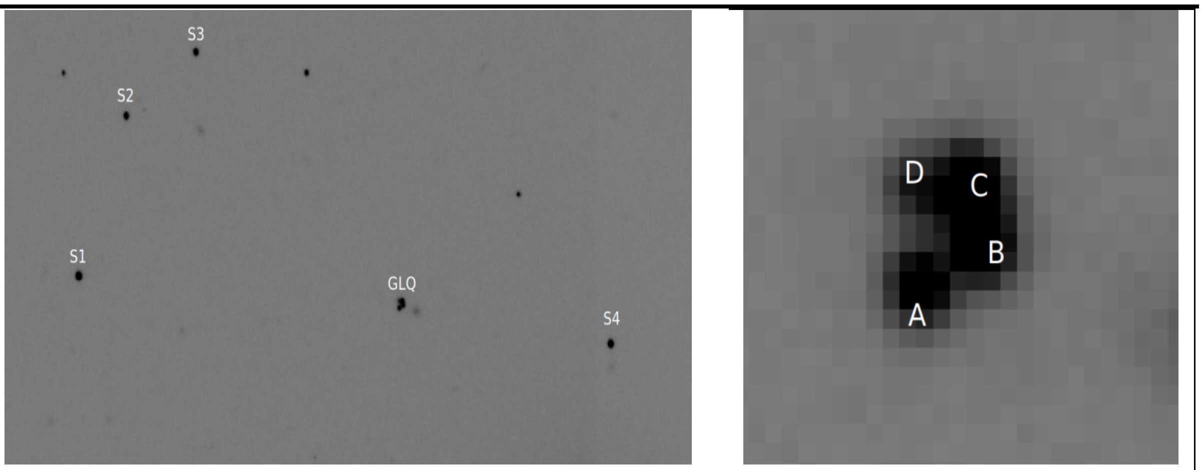

Figure 1. Image of GLK GraL J024848.7+191331 (left - large scale, right - small scale). The supporting stars are also shown. The maximum angular separation between the lensed images is 1.7 arc seconds.

The Maidanak Observatory meets all the requirements for observing the GLK. The AZT-22 telescope is equipped with a modern light detector. The initial processing of images and photometric measurements of the components were carried out within the framework of the DAOPHOT-IRAF software package. We used the Moffat function to describe the brightness distribution in point-like objects.

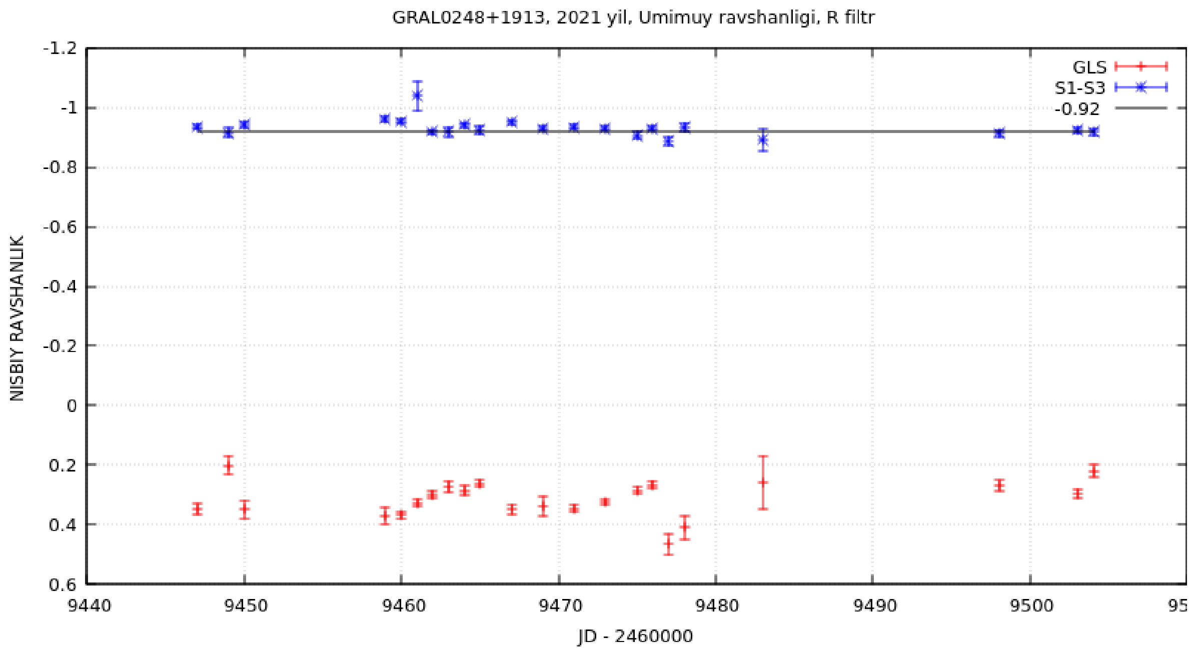

Figure 2. Above is the brightness curve of the host star, below is the change in the overall brightness of the system.

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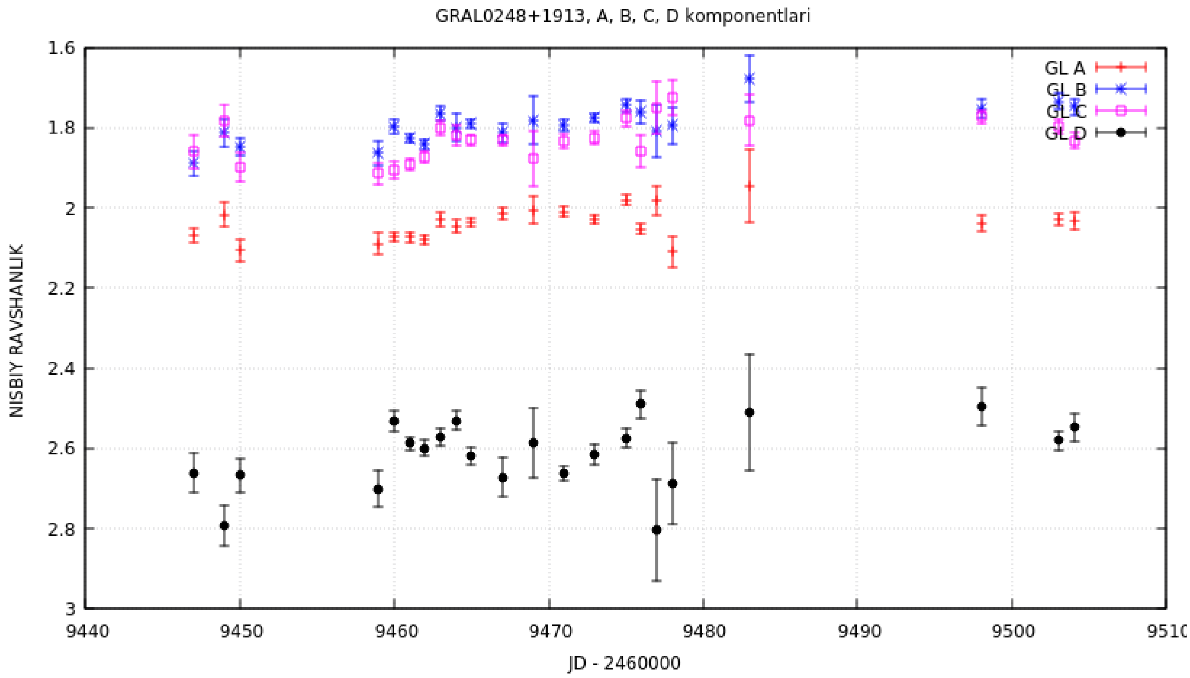

Figure 3. Brightness curves of the components in the GraL J024848.7+191331 GLK.

Figure 2 shows the overall brightness of the system and the brightness curves of the host star. We can see that the overall brightness changes like a sinusoid during the months of September-October. Since this object has four components, we can assume that microlensing effects are intense in it, like in the Einstein Cross and Cloverleaf GLKs. However, to confirm this, we will have to look at the brightness curves of each of them.

Figure 3 shows the dancing curves of the four components. It can be seen that each of them is changing independently - during the period JD=9460-9480, some of them decreased in brightness, while others slightly increased. The amplitude of the depression or increase is approximately 0.075 magnitudes. All of them differ from each other in direction and amplitude. This indicates that there is an active microlensing phenomenon in this system.

The parameters of other similar GLKs are presented in Table 1 below.

FOUR COMPONENT

N	Names	t_{BA} (day)	t_{CA} (day)	t_{DA} (day)	t_{CB} (day)	Z_s	Z_l	E(B-V)	m_s	m_l	Size (")	T_{ab} (error)
1.	B1608+656	77				1.39	0.63	0.031		19.02	2.27	1.5
2.	SDSS J1004+4112	38.4		821.6±2.1	681±15	1.734	0.68	0.013	4.4	18.42	15.99	2
3.	SDSS1029+2623	746				2.197	0.55	0.022			22.5	10
4.	WFI 2033-4723	35.3			61.3±4.1	1.66	0.66	0.047	4.4	19.71	2.33	1.2
5.	HE0435-1223	8	2.1±0.75	14.37±0.8		1.689	0.46	0.059	4.2	18.05	2.42	0.77
6.	RX J0911+0551	146				2.8	0.77	0.045	4.3	20.47	2.47	4
7.	RX J1131-1231	0.7	0.4±2.0	91.4±1.5		0.658	0.295	0.035	3.3	17.88	3.8	1.4
8.	PG 1115+080	25			23.7±3.4	1.72	0.31	3.9	18.92	2.32	0.041	2
9.	B1422+231	1.5	7.6±2.5		8.2±2	3.62	0.34	0.048	3.7	19.66	1.68	1.4

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10.	Q2237+0305	0.25	1.45	0.083		1.69	0.04	0.071	3.8	14.15	1.78	
11.	SDSS0924+0219					1.524	0.39	4.5	20.75	1.75	0.055	
12.	SDSS1011+0143					2.701	0.331		5.6	19.86	3.67	
13.	HS0810+2554					1.5		0.04	3.75	16.63	0.96	
14.	HST12531-2914						0.69	1.23	6.2	21.83	0.079	
15.	SDSS1402+6321					0.48	0.2	0.017			1.35	
16.	SDSS1406+6126					2.13	0.27	0.015	9.44	18.12	1.98	
17.	HST14113+5211					2.81	0.46	0.016	12.07	19.99	1.8	
18.	H1413+117					2.55		0.024	8.22	18.61	1.35	
19.	HST14176+5226					3.4	0.81	0.007	5.8	19.77	2.83	
20.	B1555+375							0.022	10.03	20.01	0.42	
21.	SDSS J1138+0314					2.44	0.45	0.019	4.6	20.04	1.34	
22.	WFI2026-4536					2.23		0.041	8.09		1.34	
23.	B2045+265					1.28	0.87	0.232	7.34	20.06	2.74	
24.	B0712+472					1.31	0.41	0.113	5.6	19.56	1.46	

This table lists the parameters (redshifts, delay times, color indices, apparent magnitudes of the source and object, and the greatest angular separation between the components) of the 24 most studied quadruple GLKs. Using these parameters, if we find the correlation between them, we get the following result.

Correlation

t_{ab} - z_s	t_{ab} - z_l	t_{ab} - m_s	t_{ab} - m_l	t_{ab} - size
0.166871567	0.262691378	-0.017854859	0.26688796	0.787948224
z_s - E(B-V)	**z_l - E(B-V)**	**m_s - E(B-V)**	**m_l - E(B-V)**	**size - E(B-V)**
-0.1469366	-0.157950009	0.849252677	-0.907914814	-0.217631791
z_l - z_s	**m_s - z_s**	**m_l - m_s**	**m_l - z_s**	**size - z_s**
0.233180797	-0.078584704	-0.790351598	0.286685086	0.026188771

This table shows the correlation between delay time and redshifts, delay time and apparent stellar magnitudes, redshift and color index, and other parameters. In this case, the delay time *(t_{ab})* between components A and B and the maximum angular distance *(size)* between the components are very well correlated with the apparent magnitude *(m_s)* and color index *(E(B-V))* of the source, the apparent magnitude *(m_s)* and color index *(E(B-V))* of the lens, and the apparent magnitudes of the lens and the source. From this, we can draw the following conclusion. These parameters are related to each other by some law. If we find this law and create an equation, we can use it to find the values of the parameters of other GLKs and get a lot of information about them.

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