Introduction

New estimates of the time delays in the gravitational lensing quasar QSO 2237+0305 are made from the light curves of the 2004 season in filters V, R and I. The rapid variability has been observed for the first time in the QSO 2237+0305 at the time scale of several days with the amplitudes of about 0.1-0.2 mag in filters V, R and I. QSO 2237+0305 is known to have very short differential time delays of the order of several hours (theoretical predictions).

Two images of the same quasar

Images of quasars seen through the galaxies

depending on the mutual location of a source, lens and observer, and specific spatial distribution of the lens gravitational potential.

New approach for determination of the time delays

Accuracy constraints of time delays determination:
- the presence of systematic and random errors in light measurements of the quasar component;
- small amplitudes of the quasar intrinsic brightness variations;
- irregular sampling of light curves and large seasonal gaps;
- microlensing events associated with isolated compact masses in the lensing galaxy which has the most serious effect on the bias and accuracy of the time delays.

Advantages of the proposed method
- Representation of light curves in the form of series expansions in orthogonal polynomials was applied.
- For utilizing the useful properties of the orthogonal-polynomial regressions, an orthonormal basis specified at a discrete set of unevenly spaced data points (dates of observations) was constructed with the use of Gramm-Schmidt orthogonalization procedure (Legendre polynomials - for the computational stability).

The essence of the proposed method

The example of initial light curves and their representations in the form of series expansions in Legendre polynomials.

The time delays from the light curves in filters R and I are well consistent with each other, while those from the V light curves differ noticeably. We assume this can be explained by the presence within the filter V of the broad spectral features that may help to distinguish between various mechanisms of the quasar variability; serious effect on the bias and accuracy of the time delays.

The first three lines - the time delays for QSO 2237+0305 (hours) in filters V, R and I. The last three lines - model predictions (recent works) with the values in brackets calculated from the original quantities (using the relationship between the time delays).

Conclusions

- The novelty of the proposed method consists in using the fundamental properties of the functions approximation by series expansion in the orthogonal polynomials (Tsvetkova et al. 2016). This ensures the best approximation to the observed light curves and provides a simple way to mitigate the effects of slow microlensing.
- Rapid intrinsic variability has been detected for the first time in the QSO 2237+0305 with amplitudes of about 0.1-0.2 mag. The short-time scale of the events has made it possible to determine the differential time delays, which are more accurate and better consistent with the most recent theoretical predictions.
- The time delays measured from the light curves in filter V exhibit some correlation, which may be due to the presence of the broad emission line CII) within the V-band.