K and M-dwarf Eclipsing Binaries in SDSS Stripe 82

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Introduction

We present model fits and estimated light-curve parameters for a set of four low-mass eclipsing binaries discovered in SDSS Stripe 82 as part of a general search for periodic variables in this dataset. These objects have small orbital periods, thus are relatively well-covered in phase, minimizing the difficulties posed by sparse and uneven time-sampling of SDSS photometry in this region.

We model these objects' SDSS *r* and *i* light-curves using the Wilson-Devinney code (Wilson & Devinney 1971) and obtain estimates of the following for each system: the ratio of the sum of stellar radii to semi major axis *(R1+R2)/a*, the ratio of the stellar radii *R1/R2*, the luminosity ratio *L1/L2*, the mean stellar surface temperature ratio *T1/T2* and the inclination of the binary orbit *i*.

Data from SDSS Stripe 82

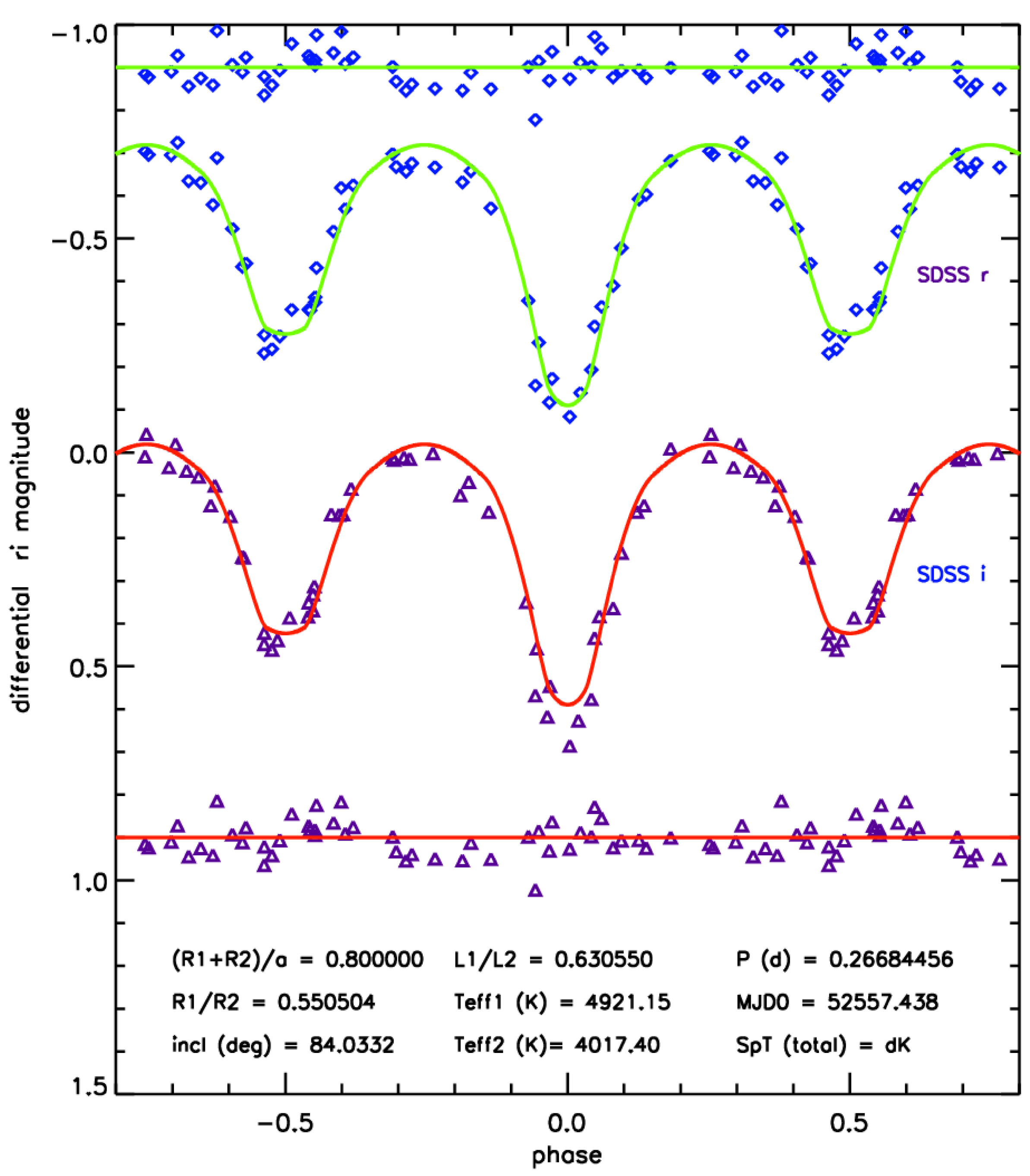
We used object detection catalogs generated by the SDSS photometric pipeline to generate light-curves of all point sources detected in all five SDSS bands brighter than $r \sim 22.0$. Robust variability detection and period search techniques were then employed to search for periodic variables, with special attention devoted to examples of eclipsing binary systems. The excellent color selection using Sloan filters allowed positive identification of low mass dwarf stars (see Yanny et al. 2008, and West et al. 2008).

We detected nearly 150 examples of eclipsing binary systems. Of these, approximately 100 objects have robustly determined orbital periods. K-dwarf EBs appear to be the most common, followed closely by systems composed of M-dwarfs. In addition to these objects, we have identified ~250 other periodic variables, including RR Lyrae, high amplitude Delta Scuti variables, photometrically variable rotating stars, and several ellipsoidal binaries. Part of the data has been made public (Bhatti et al. 2010), with the remainder to follow shortly.

The sparse phase coverage of the dataset introduces a bias towards small orbital periods. As a result, much of our binary sample is composed of objects with periods less than 1.0 day, with a large number of objects having periods in the interval $0.2 < p < 0.3$ days.

The objects discussed here illustrate one use of this rich dataset: preliminary modeling of eclipsing binaries utilizing multi-filter photometric light-curves.

SDSS J031021.22+001453.9



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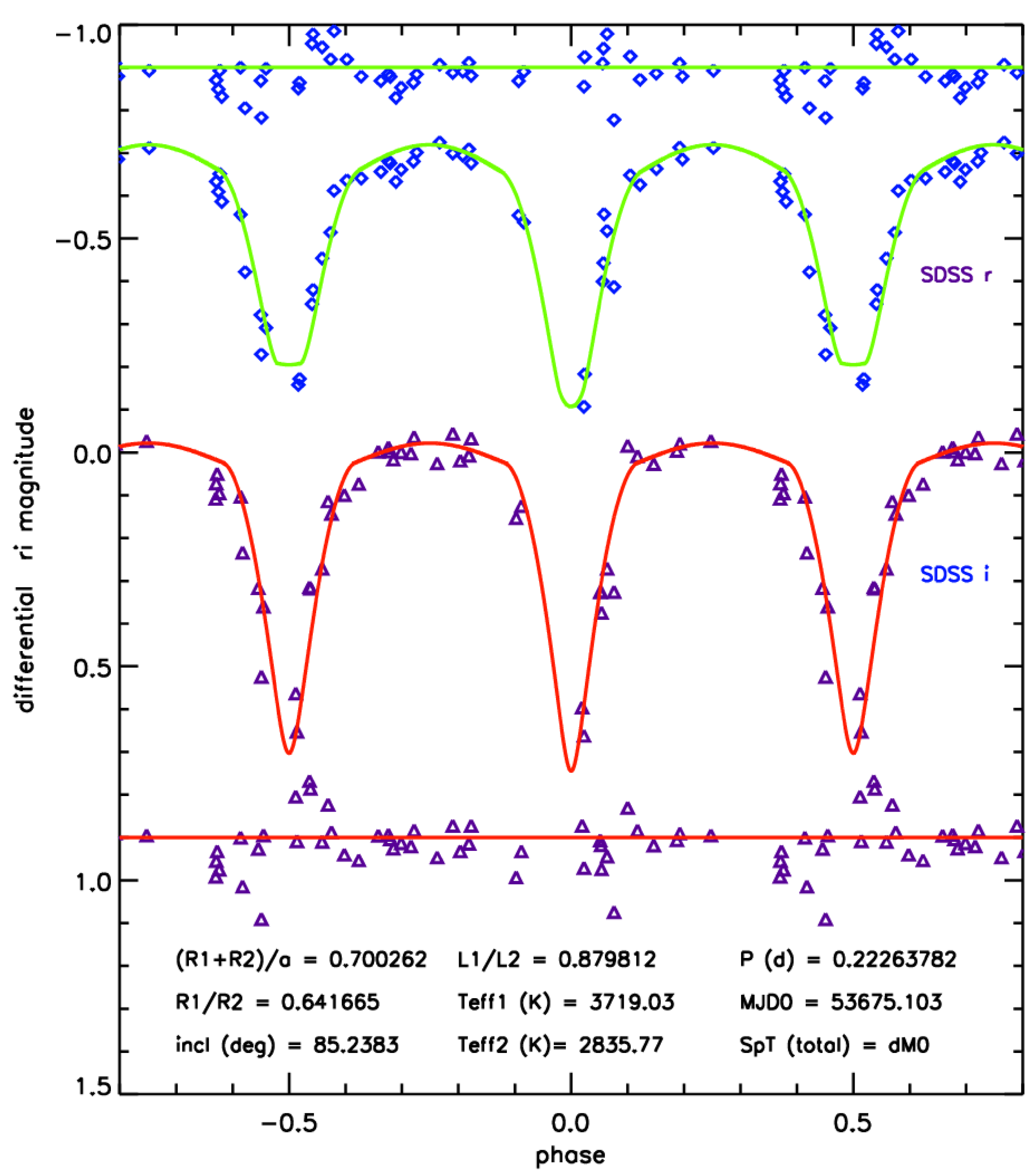

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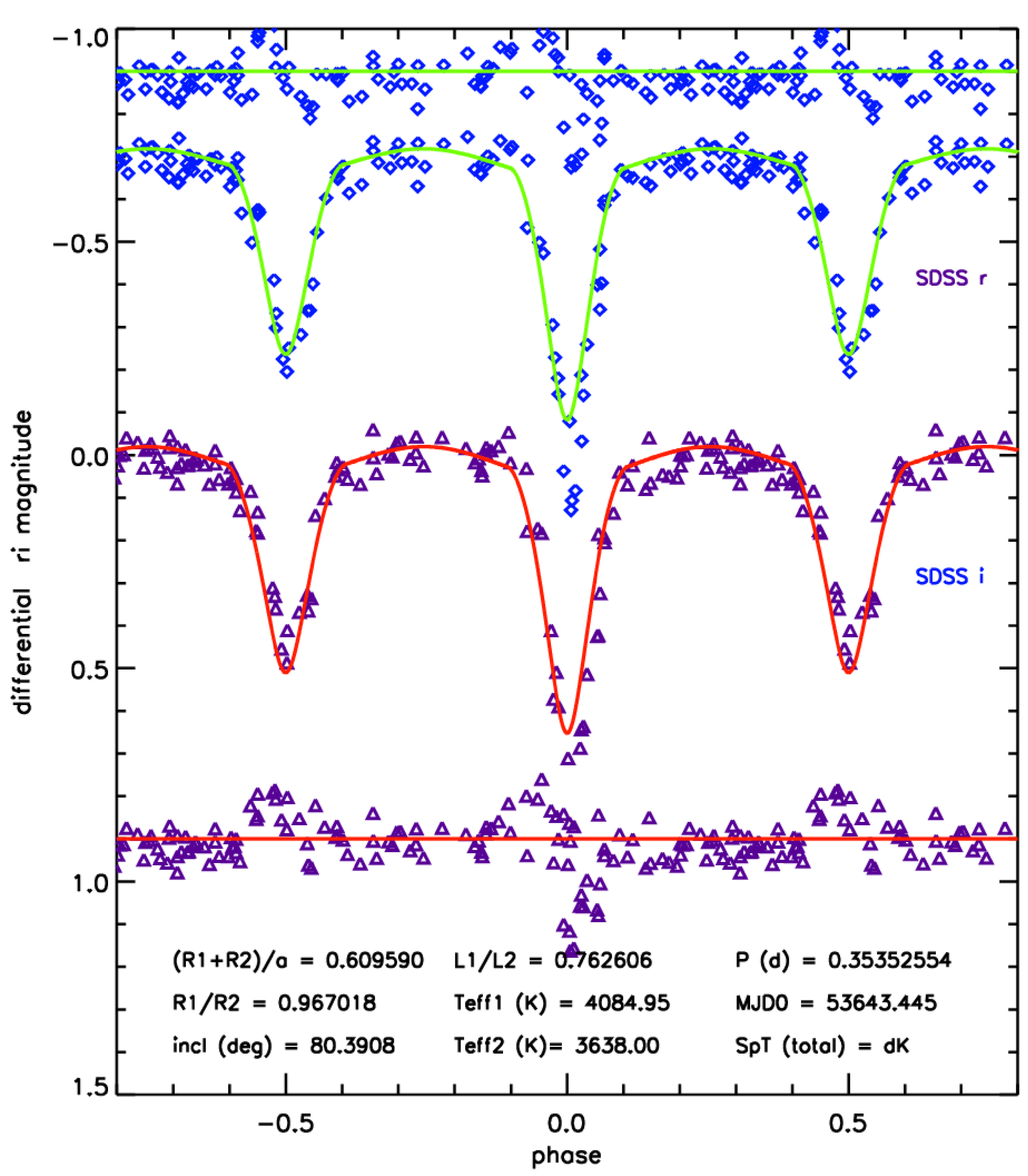

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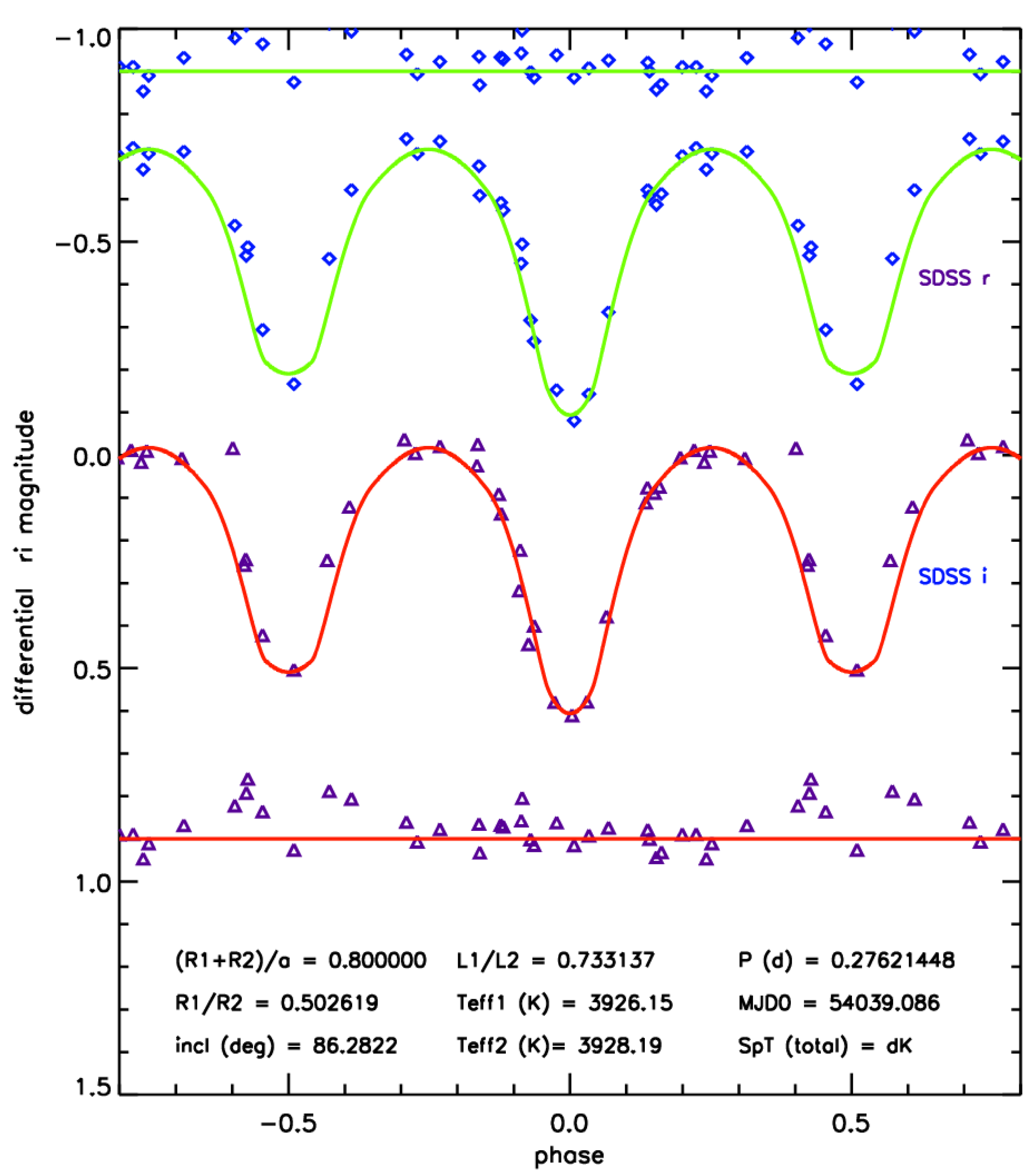

Modeling the Binary Systems

We first estimate the parameters *(R1+R2)/a*, *R1/R2*, *L1/L2*, and inclination from geometrical fits to the light-curves. The mean surface temperature ratio *T1/T2* is calculated using pairs of SDSS *r-i* color indices at the phases of primary eclipse and quadrature. We assume a zero eccentricity and synchronous rotation for the binary components on account of their small orbital periods.

These initial guesses are then used as input for the standard Wilson-Devinney eclipsing binary modeling code (Wilson & Devinney 1971, most recently updated in 2007). We use the Claret (2004) stellar atmosphere models, and generate a set of artificial differential magnitude light-curves in the SDSS *r* and *i* bands.

We solve the optimization problem (simultaneously for the *r* and *i* light-curves) by using the downhill simplex method (AMOEBA, Press et al. 1992). The Levenberg-Marquardt minimization algorithm is then used to refine the parameters obtained by this initial search. Error estimates for the fit parameters are obtained by adding Gaussian perturbations, and repeating the modeling and optimization process many times to obtain a range of values, and thus formal 1-sigma error estimates.

The systematic uncertainties in our estimates of inclination and time of minimum for each binary system will dominate these formal errors. These arise due to the sparse coverage of eclipse phases in the Stripe 82 dataset, resulting in ambiguously designated times of primary minima.

Conclusions and Future Work

The parameters estimated from the light-curves of the four objects discussed here will help detailed modeling efforts that will be carried out after photometric and spectroscopic followup of these objects. The relative faintness of these targets, however, poses a challenge for radial velocity measurements. We are currently conducting a spectroscopic campaign to measure the radial velocities of these as well as several other targets in our sample with the eventual goal of securing precise estimates of the masses and radii of the low mass stars in these binaries.

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http://shrike.pha.jhu.edu/stripe82-variables/

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