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Solving the puzzle of discrepant variability on monthly time scales implied by SDSS and CRTS datasets

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ABSTRACT

We present improved error analysis for the 3,800 CRTS (Catalina Real-Time Transient Survey) optical quasar light curves from the Sloan Digital Sky Survey Stripe 82 catalog. SDSS imaging survey has provided a time-resolved photometric dataset which greatly improved our understanding of the quasar optical continuum variability: data for monthly and longer timescales are consistent with a damped random walk. Recently, newer data obtained by CRTS (Catalina Real-Time Transient Survey) provided puzzling evidence for enhanced variability, compared to SDSS results, on monthly time scales. Quantitatively, SDSS results predict about 0.06 mag rms variability for timescales below 50 days, while CRTS data show about a factor of two larger root-mean-square for spectroscopically confirmed SDSS quasars. Our analysis presented here has successfully resolved this discrepancy as due to slightly underestimated photometric error estimates provided by the CRTS image processing pipelines. The photometric error correction factors, derived from detailed analysis of non-variable SDSS standard stars that were re-observed by CRTS, are about $20-30\%$, and result in a quasar variability behavior implied by the CRTS data fully consistent with earlier SDSS results.

1 INTRODUCTION

Variability can be used to both characterize and select quasars in sky surveys . Ahtough various timescales of variability can be linked to physical parameters, such as accretion disk viscosity, or corona geometry (Kelly+2011, Graham+2014), the physical mechanism remains elusive, and most viable explanations include accretion disk instabilities (Kawaguchi + 1998), surface thermal fluctuations from magnetic field turbulence (Kelly+2009), coronal x-ray heating (Kelly+2011) (see Kozlowski 2016 for review). The diversity of physical scenarios explaining the origin of quasar variability led to a plethore of ways to characterize the varying brightness. The two most widely used approaches to describe variability of quasars are damped random walk (DRW) and structure function. The DRW model is more suited for lightcurves with typical cadence of days (Zu+2013, Kozłowski+2016), whereas an ensemble SF analysis is better for sparsely sampled lightcurves (Hawkins 2002, Vanden Berk 2004 , de Vries 2005, Schmidt 2010, Graham 2014, or review in Kozlowski 2016). Although CRTS data has been used for both an SF and DRW analysis [CITE WHERE], we use the SF approach, as more robust for sparsely sampled lightcurves than the DRW. [For a recent overview of the context for variability studies, see Lawrence+2016.]

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