Probing Accretion Processes Through Variability

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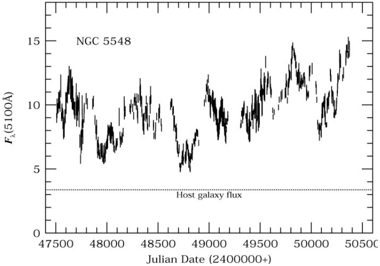
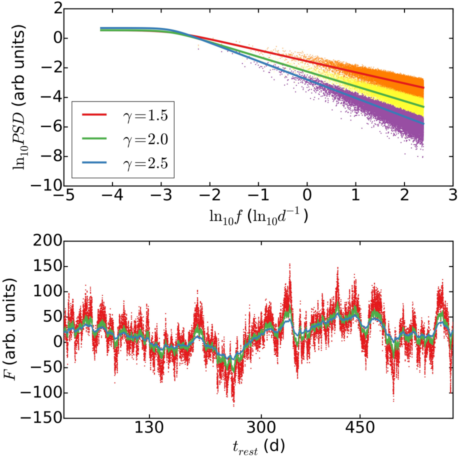
Accretion Characteristic: Rapid, Stochastic, Luminosity Variations
(and we do not know why!)

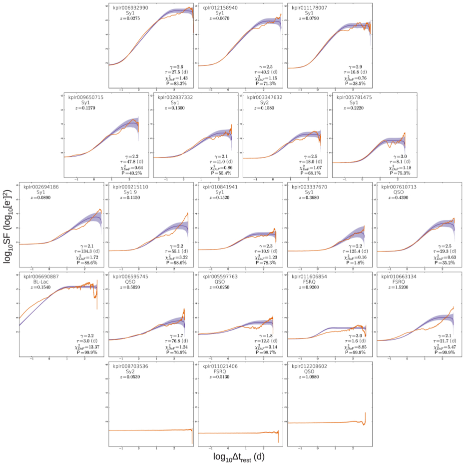


(Peterson et al. 1999)

- ~ 90 % of AGN vary (Sesar et al. 2007)
- Pan-spectral: shorter $\lambda \Rightarrow$ stronger variability
- Stochastic! (Peterson 1997)
- λ_{long} lag λ_{short} (but sometimes backwards!)
- What can TMT contribute?

Beyond the Damped Random Walk



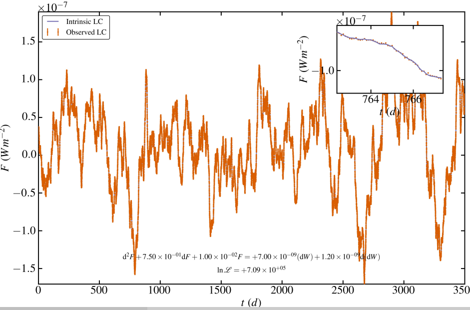


Continuous-time AutoRegressive Moving Average (C-ARMA) Processes

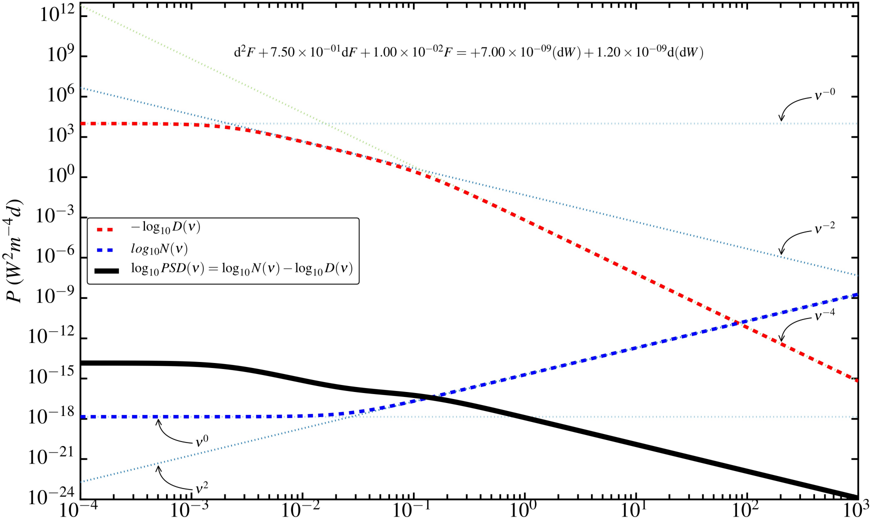
$$\mathrm{d}W \sim \mathcal{N}(0, \mathrm{d}t)$$

$$\mathrm{d}^p x + \alpha_1 \mathrm{d}^{p-1} x + \ldots + \alpha_{p-1} \mathrm{d}x + \alpha_p x = \beta_0(\mathrm{d}W) + \ldots + \beta_q \mathrm{d}^q(\mathrm{d}W)$$

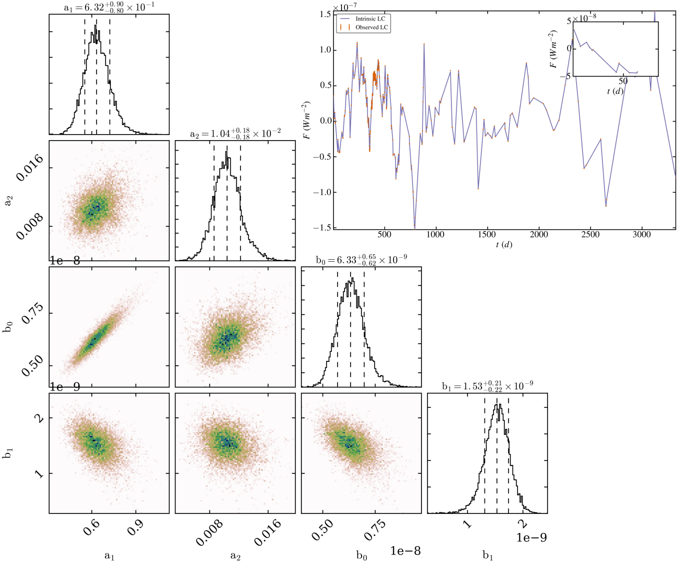
- Uses Itō calculus Davis (2002); Brockwell (2014); Kelly et al. (2014)
- RHS: Correlation structure of all perturbations.
- LHS: Evolution of individual perturbations.
- PSD: ratio of even polynomials of frequency.



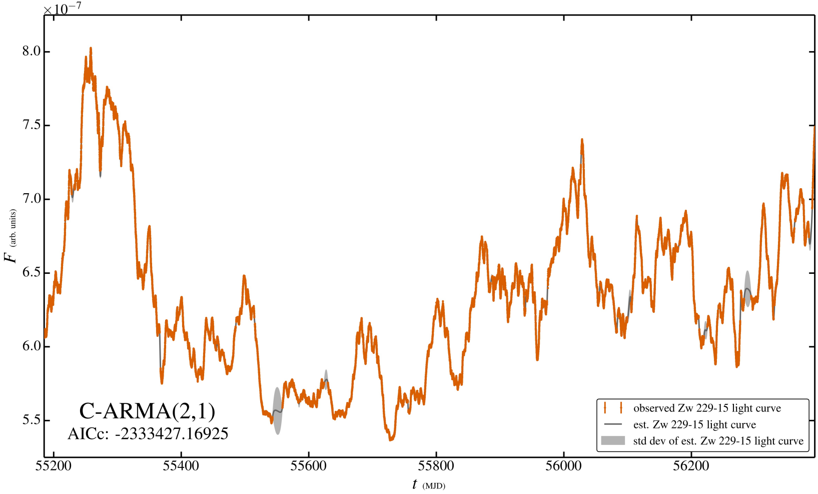
Power Spectral Density
Eg. C-ARMA(2,1)



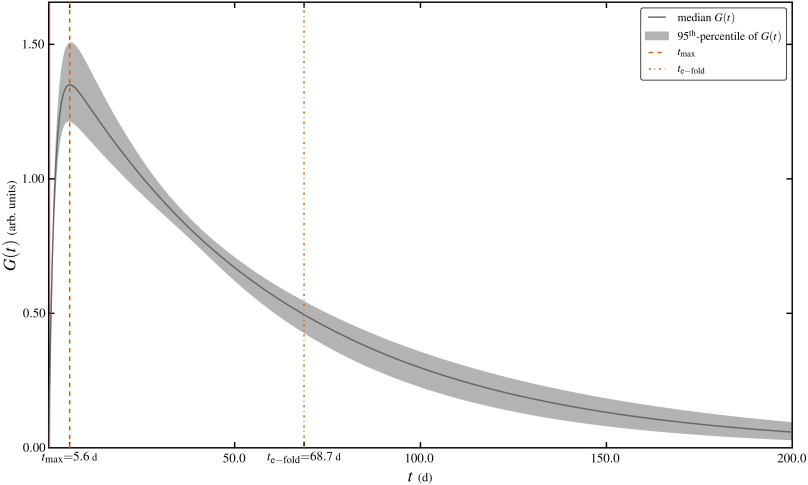
Confidence Interval Estimates



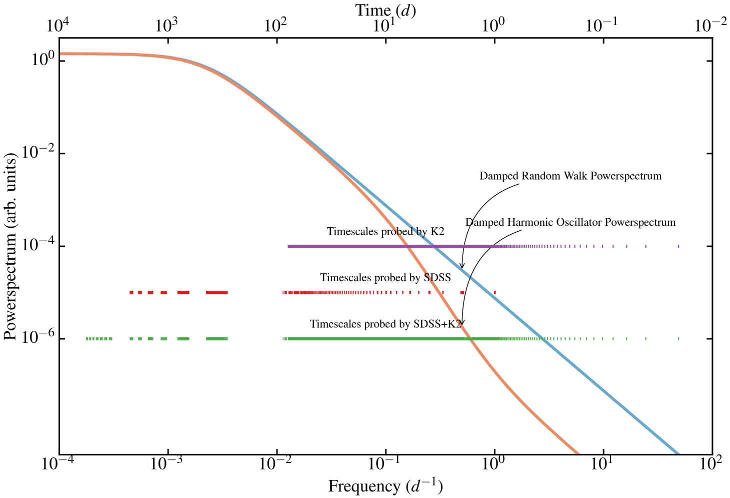
C-ARMA(2,1) model of Zw 229-15
Smoothed light curve



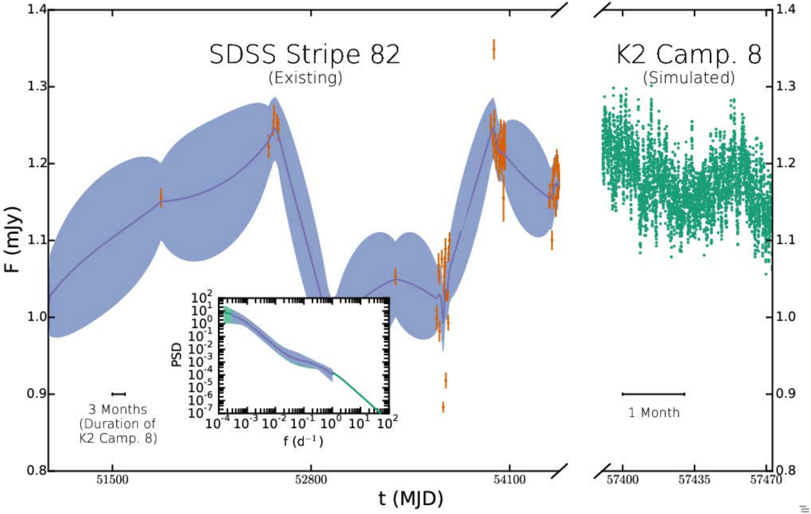
C-ARMA(2,1) model of Zw 229-15
Green's Function



Prototype for LSST+TMT: Combining SDSS with K2



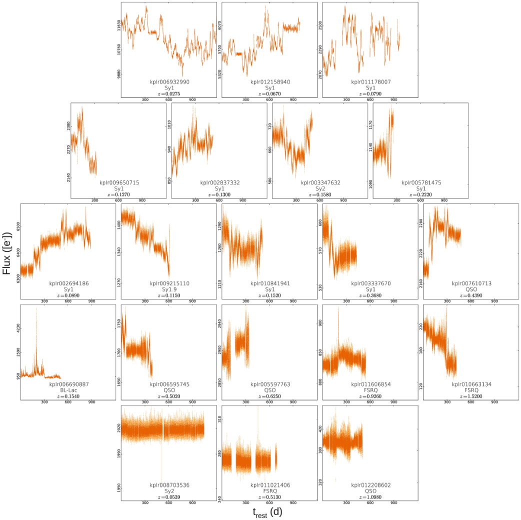
Prototype for LSST+TMT: K2 observations of Stripe 82 QSOs



Conclusions

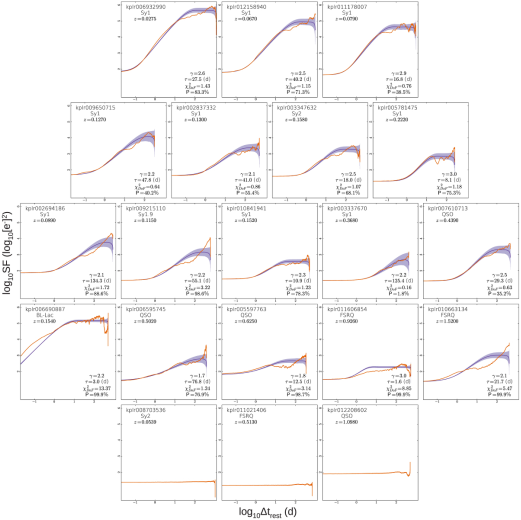
- We need good data!
- Good data shows: DRW does **not work** for all AGN
- Variability $\Rightarrow$ C-ARMA process
- C-ARMA(2,1) process $\Rightarrow$ Zw 229-15 variability
- Zw 229-15 $\Rightarrow$ **Damped Harmonic Oscillator + Colored Noise**
- Future time-domain surveys: **combine multiple data sources**
- TMT: Rapid sampling + low noise
- LSST: Long baseline

Full AGN sample



- $z \sim 0.02\text{-}1.5$
- $\delta t_{\mathrm{rest}} \sim$ 14-28 min
- $N \sim$ 16k-60k
- Wide variety of behavior!

Structure Function fits



- Not all AGN ~ DRW
- PSD model too simple
- Variability onsets over ~ 1 hr to ~ 1 d

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