# Characterisation of Radio Transients using Gaussian Processes

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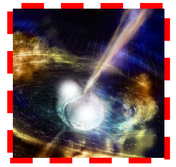
## Twinkle twinkle little star…



Exotic phenomena

Large-scale survey

Raw Data → $10^3$ to $>10^6$ sources

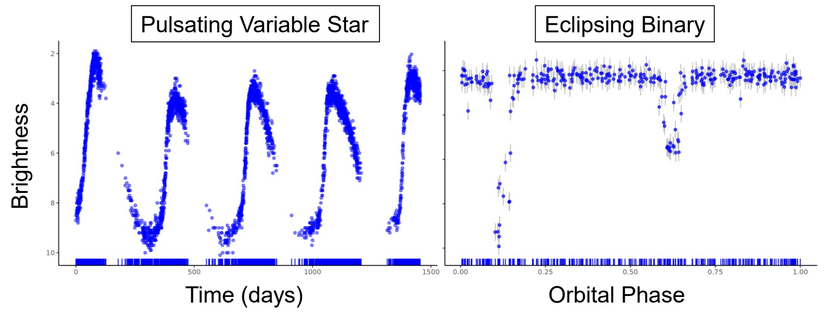
Identify → Transient candidates

Classify → **... how I wonder what you are?**

Encode the variability of a source in a way that is **concise**, **robust,** and **descriptive**.

## 1. Light curves as stochastic processes

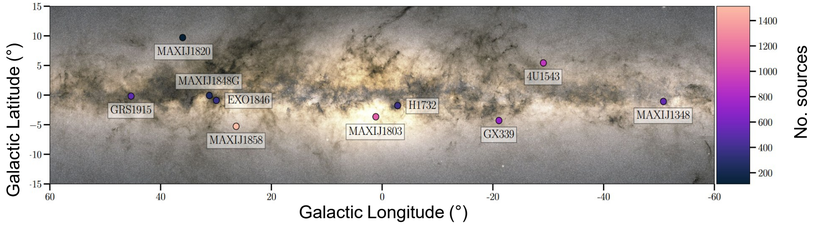
Light curves are time series describing the brightness of a source over time.

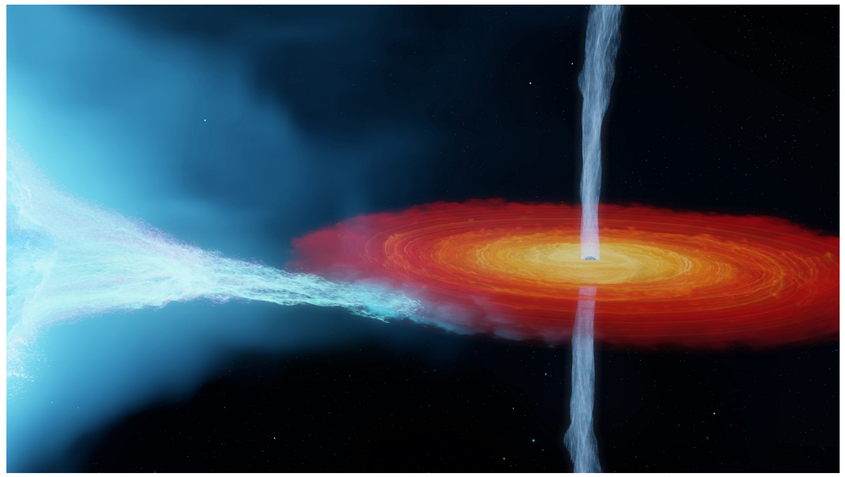



## 2. ThunderKAT Survey

- MeerKAT Image-domain transients survey.
- 6,394 radio light curves over 10 fields.

MeerKAT Radio Telescope (SARAO)



Artist's impression of Cygnus X-1, an accreting X-ray binary system (ICRAR)

## 3. Bayesian Hierarchical Model

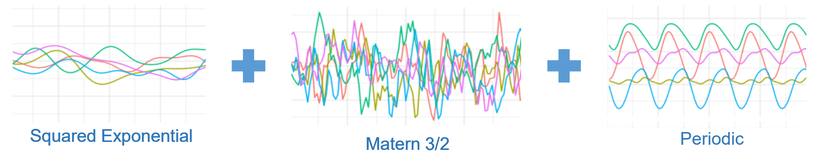
$$S_i \sim N(f_i, \hat{e}_i^2)$$ Observed flux density

$$\boldsymbol{f} \sim GP(\boldsymbol{0}, \boldsymbol{K}_{n\times n})$$ Gaussian process prior

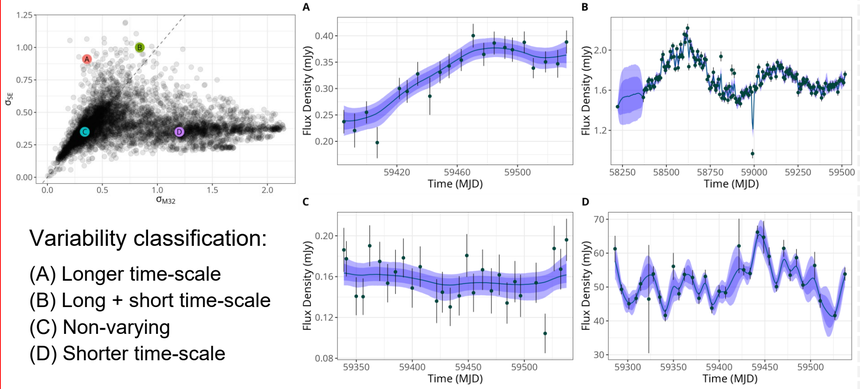
$$i, r, c = 1, \cdots, n. \quad \tau = |t_r - t_c|$$

$$[\boldsymbol{K}]_{rc} = \kappa(t_r, t_c|\boldsymbol{\theta})$$ Covariance Kernel

$$= \kappa_1(\tau|\sigma_{SE}, \ell_{SE}) + \kappa_2(\tau|\sigma_{M32}, \ell_{M32}) + \kappa_3(\tau|\sigma_P, \ell_P, T)$$



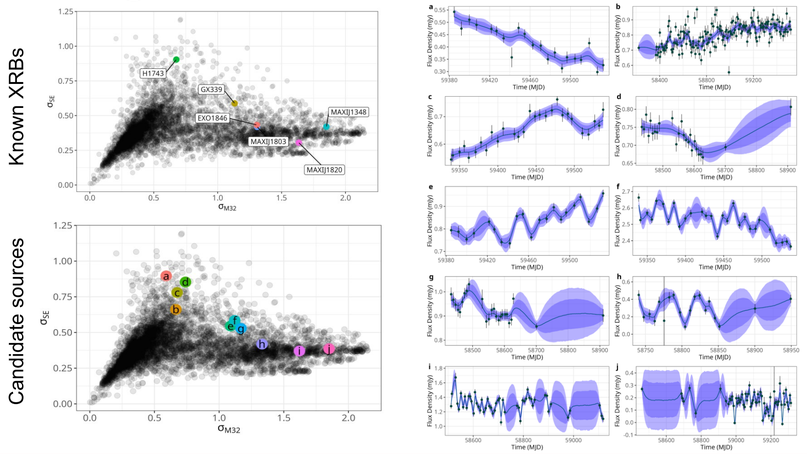

## 4. Explore the Amplitude Space




Variability classification:

(A) Longer time-scale
(B) Long + short time-scale
(C) Non-varying
(D) Shorter time-scale

## 5. Neighbourhood Search




## ... a Gaussian process is what you are!

- To identify transients in large surveys we need a statistical representation that is **concise**, **robust**, and **descriptive**.
- We can tune **multi-term kernels** for different behaviours and scales.
- Kernel **amplitude** hyperparameters ($\sigma_{M32}$, $\sigma_{SE}$) seem to encode the **transience** of sources.

https://doi.org/10.3847/1538-4357/adfb79