# When is a noisy signal Oscillating and when is it just noisy?


## Student name: Ritesh Balayan / Supervisor: Dr Peter Swain

THE UNIVERSITY *of* EDINBURGH
School of Physics
& Astronomy

THE UNIVERSITY *of* EDINBURGH
Centre for Engineering Biology

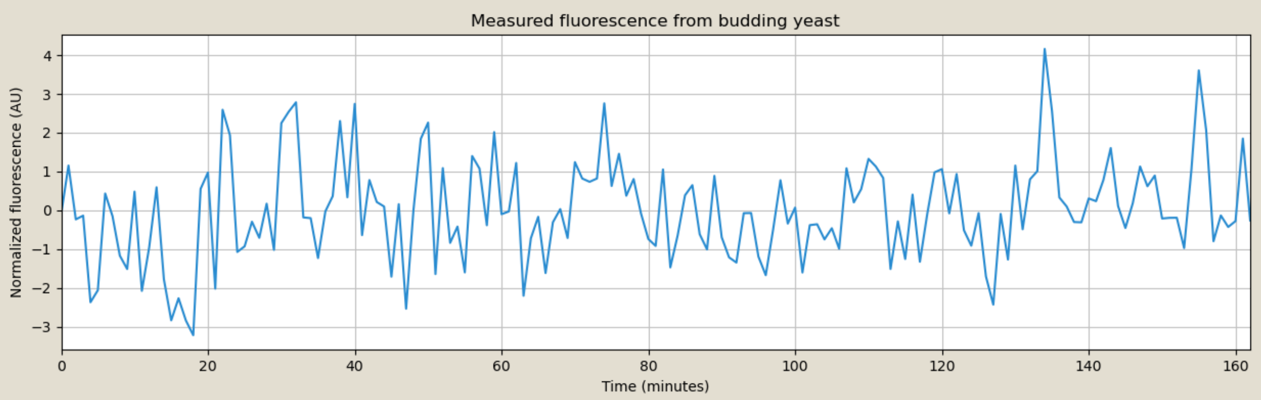


### *Abstract*

*Generating rhythms is a fundamental property of life. Even at the cellular level, yeast cells display metabolic oscillations during growth and division. However, detecting these oscillations from noisy time series data can be challenging. This poster proposes a study to extend Bayesian inference, a statistical physics technique commonly used in astrophysics, to detect these oscillations in measured rhythms of budding yeast. We will also use Monte Carlo methods to infer best-fit parameters and exploit Gaussian distributions. By applying this approach, we aim to gain insights into the mechanisms underlying these rhythms, with implications for understanding the principles governing living systems.*


### *Description*

My aim is to develop an algorithm that can replicate the classifications made by a human expert. We will utilize Bayesian inference techniques to achieve this goal. Following is the example of data we will be working on.




### *Methodology*

Swain Labs has a vast collection of recorded data, which we will use to train and verify our inference methods before making the algorithm compatible with any unknown data structure. Initially, we will develop the algorithm's scripts using raw Python and later incorporate advanced libraries. Our plan is to achieve flawless analysis by using a combination of Swain Labs' and externally developed packages.

### *Idea*

Bayesian hierarchal structure will be used to optimise fit the fit. Model will be encapsulated by gaussian process. Which makes optimisation parameter free.

$$\mathcal{P}(\mathcal{H}_i|\boldsymbol{y},\boldsymbol{\theta}) = \frac{\mathcal{P}(\boldsymbol{y}|\mathcal{H}_i)\mathcal{P}(\mathcal{H}_i|\boldsymbol{\theta})}{\mathcal{P}(\boldsymbol{y}|\boldsymbol{\theta},\mathcal{H}_i)}$$

Where $\mathcal{P}(\boldsymbol{y}|\boldsymbol{\theta},\mathcal{H}_i) = \int \mathcal{P}(\boldsymbol{y}|\mathcal{H}_i)\mathcal{P}(\mathcal{H}_i|\boldsymbol{\theta})d\mathcal{H}_i$

$\mathcal{P}(a|b)$ reads probability of a given b
$\mathcal{H}_i$ = Model of budding yeast
$\boldsymbol{y}$ = Experimental data
$\boldsymbol{\theta}$ = Hyper-parameters of Model


| Task | Week |
|---|---|
| Literature Review | Semester 2 |
| Primitive Algorithm Implementation | Week 1 -2 |
| Report *(Introduction and Limitation of early results)* | Week 2-3 |
| Brain storming again | Week 4 |
| Optimising techniques (*Reporting results on the go)* | Week 4-8 |
| Organising Report and debugging codes | Week 9 |
| Presentation practice and Report modification | Week 10-11 |
| Presenting Findings to world | Week 11-12 |

### *Schedule*

I plan to gain experience with standard inference algorithms by learning to implement them, which will reveal their limitations and guide further reading and implementation. Beginning with a theoretical understanding of machine learning techniques, I will modify them based on my experience from initial tests before implementing them.

### *Report Structure*

The report will describe the challenges of observing oscillations in complex physical systems, focusing on a specific problem related to astrophysics and the added complexity in biological systems. It will also provide an overview of current machine learning techniques and implementation challenges. The second half of the report will present findings from July.