

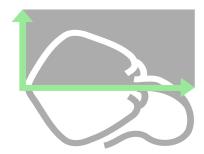








- Stingray is an open-source Github-based software package designed to perform time series analyses and related task on astronomical light curves.
- Great performance (Lai et al. in prep.)
- Complicated spectral-timing analyses in a simple way:
 - Check your results
 - Get acquainted with such methods



Spectral-Timing made easy with Stingray



Eleonora Veronica Lai, Matteo Bachetti, Daniela Huppenkothen, Matteo Lucchini, Guglielmo Mastroserio and the Stingray community

Stingray is an open source GitHub-based Python library for time series analysis of astronomica light curves. It provides a range of the commonly used Fourier techniques, alongside dedicated tools for pulsar studies, simulating data sets, and statistical modelling. Stingray is designed to be both extensible and easily integrated into existing workflows and pipelines, making it a

Stingray was conceived at the 2016 workshop The X-ray Spectral Timing Revolution, when a group of X-ray astronomers and developers joined forces to create a shared, open-source platform for timing analysis in Python. At the time, most X-ray timing relied or custom or proprietary tools. The aim was to merge existing efforts nto a package that followed modern open-source practices, offered both scripting and graphical interfaces, and provided a solid atistical foundation for advanced spectral-timing techniques Stingray's ultimate goal is to provide the community with a packag

Subsequent developments included HENDRICS, extending

functionality for pulsar searches and command-line use, and DAVE, a graphical interface project. For a more complete overview of

Stingray is designed to provide advanced tools tailored to the neer of the high-energy astrophysics community, while remaining flexible and extensible through general-purpose classes and methods Ongoing work, supported by the Italian National Recovery and Resilience Plan, focuses on boosting performance via GPUs and parallel computing. Futur developments will include a major redesign of the modelling subpackage, integrating cutting-edge

Application example (Lai et al. 2022, MNRAS, 512, 2671 Spectral-timing analyses of XMM-Newton data in the hard state of Cyg X-1 highlights the impact of the stellar wind on variability properties of the source.

1. Data handling and simulation

Newton/EPIC NICER/XTI)

Time Lags and Coherence

Loading event lists from FITS files (and generally good handling OGIP-compliant missions, like RXTE/PCA, NuSTAR/FPM, XMM

Periodograms and Cross spectra with different techniques (single, Bartlett, Multi-Taper, Lomb-Scargle) and different

normalisations (Leahy, fractional rms, absolute rms, ...)

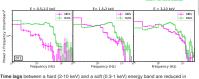
Variability-Energy spectra, like covariance/lag spectra

Simulating realistic light curves and event lists

Dynamical periodograms and cross spectra
Maximum-likelihood fitting of periodograms

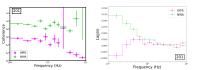
 Pulsar searches with Epoch Folding and Z²_e Gaussian Processes for QPO studies Cross correlation functions





particular, the power spectrum shows enhanced fractional rms at low frequencies (~0.1-1 Hz) due to the presence of the stellar wind and sup

amplitude, while pronounced soft lags emerge at low frequencies during intervals of strong sorption due to the wind. The **coherence** between the same energy bands, usually close unity, drops significantly in the presence of the stellar wind, reflecting a more complex and non linear variability counling. These results demonstrate how such analyses can disentangle intrinsic



notebooks that can be executed and adapted to

Do you have an issue or a feature request? Do you want to contribute? Or maybe you are just curious about the details of the code? You











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Need help? Look for me during coffee breaks. For sure you will find me close to the **pistacchio** sweets!

