



Time Series and the VO

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Why Time Series?

Projects:

Project	Coordinator	Status
ObsTap	David Schade	monitoring implementation
SED Builder	Evanthia Hatziminaoglou and Paolo Padovani	
Search for Classes/List of Objects	Mark Allen	monitoring implementation

Projects in Development:

Project	Status	
Time Series	Collecting use cases and collating existing information	Use Case development page
Radio Astronomy	Collecting use cases	Use Case development page

IVOA Committee on Science Priorities. The primary objective of the CSP “is to identify research needs of the worldwide astronomy community than can benefit from VO related tools and services, and to take action within the context of the IVOA to assist in placing such tools and services into the research community.”

Why Time Series?

Motivation I: There are many.

- ✓ The number of time series has enormously increased in the last years.

Motivation II: They are important.

- ✓ Time domain science encompasses every area of astronomy, from Solar System to cosmology.

Motivation I

Time Series everywhere



SuperWASP

>17 million light curves

OGLE

> 40 million objects



The All Sky Automated Survey

> 10 million objects



Time Series everywhere

- Ground-based projects (II)

Robotic Telescopes of the World

<http://www.uni-sw.gwdg.de/~hessman/kml/index.html>



128 Robotic Telescope Projects

Time Series everywhere

- Ground-based projects (III): The future



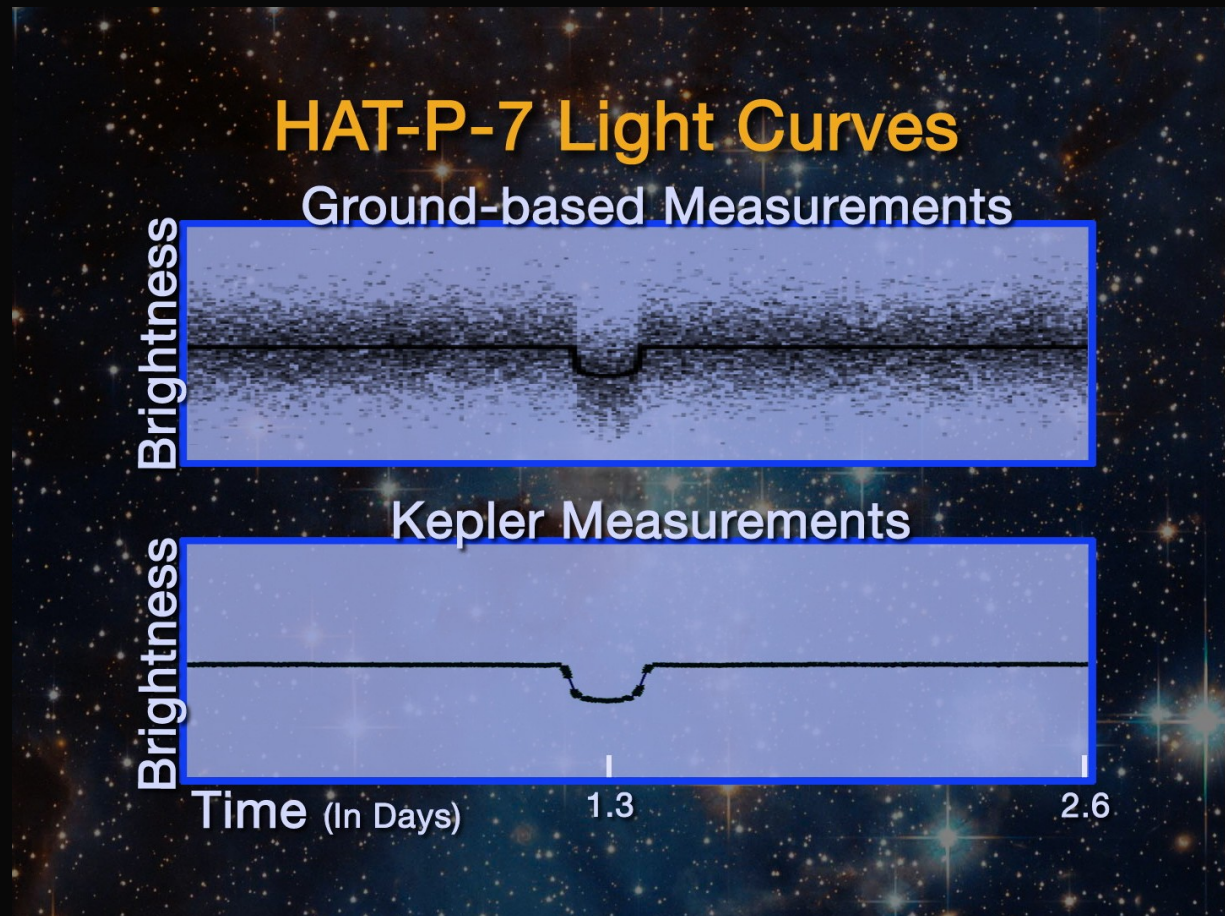
- A 3.2 gigapixel, 15-second exposure image every 20 seconds.
- 200000 images (1.28 PB/y).

Time Series everywhere

Space-based projects:

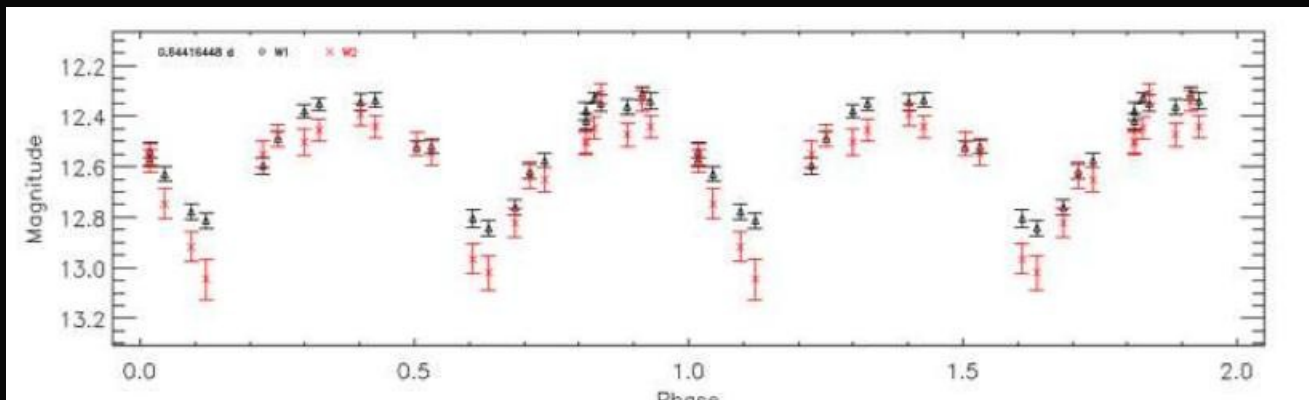
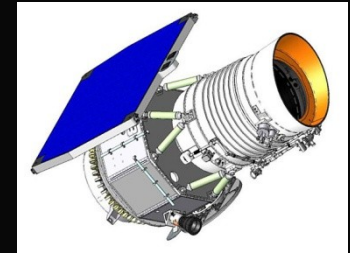
- ✓ Unprecedented photometric accuracy and time sampling.

CoRoT, Kepler

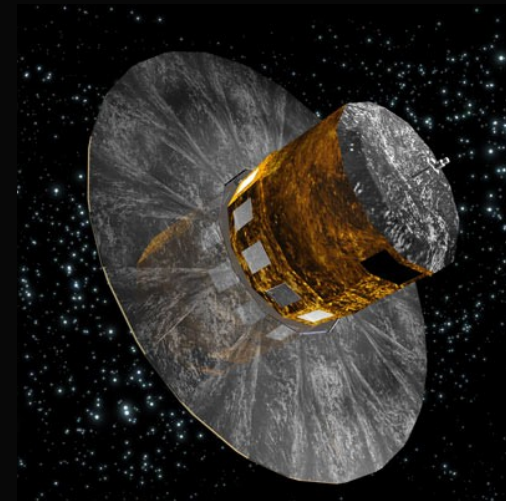


Time Series everywhere

- Space-based projects (III):
 - New spectral windows: **WISE**



- **The future: Gaia**
 - ✓ Multi-epoch, multi-color photometry for 10^9 sources.

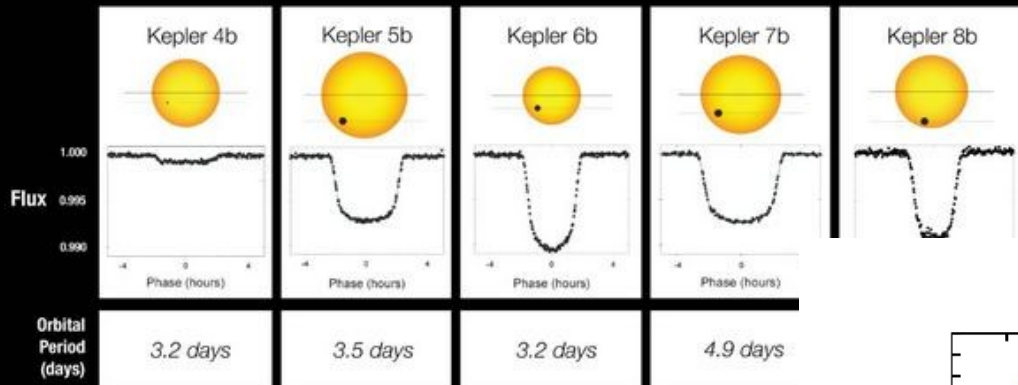


Motivation II

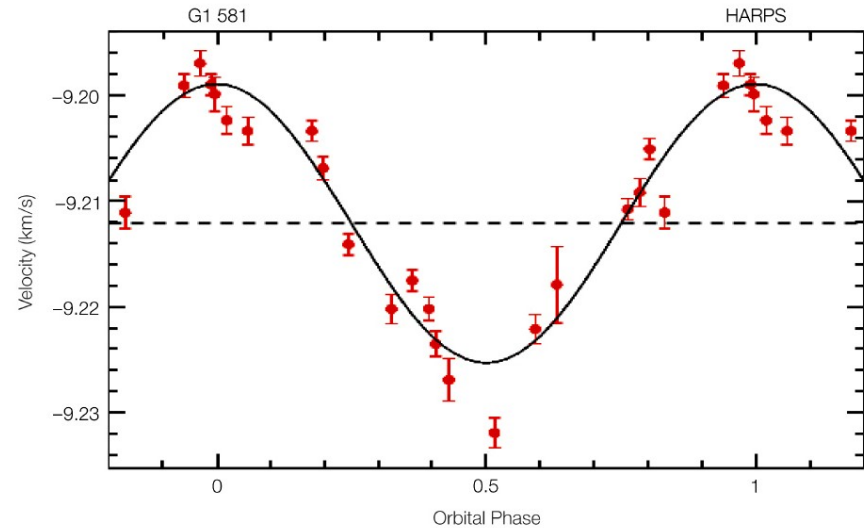
Time Series for everything

- Discovery and characterization of extrasolar planets

Transit Light Curves



Radial velocity



Time Series for everything

Asteroseismology

A&A 435, 955–965 (2005)
DOI: 10.1051/0004-6361:20042480
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Astronomy
&
Astrophysics

Detection of 75+ pulsation frequencies in the δ Sct

Abstract Extensive photometric monitoring of the δ Sct star HD 174936 in 2004, 926 h of photometry at the millimagnitude level, excellent frequency resolution and high time resolution, set a new record for this type of star. The modes

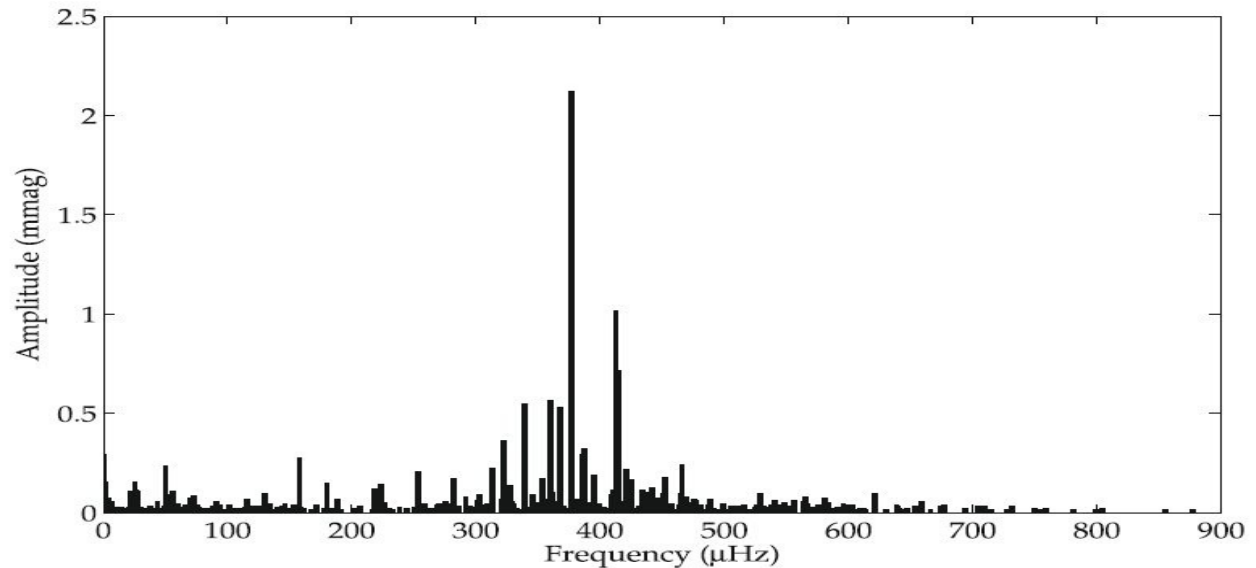
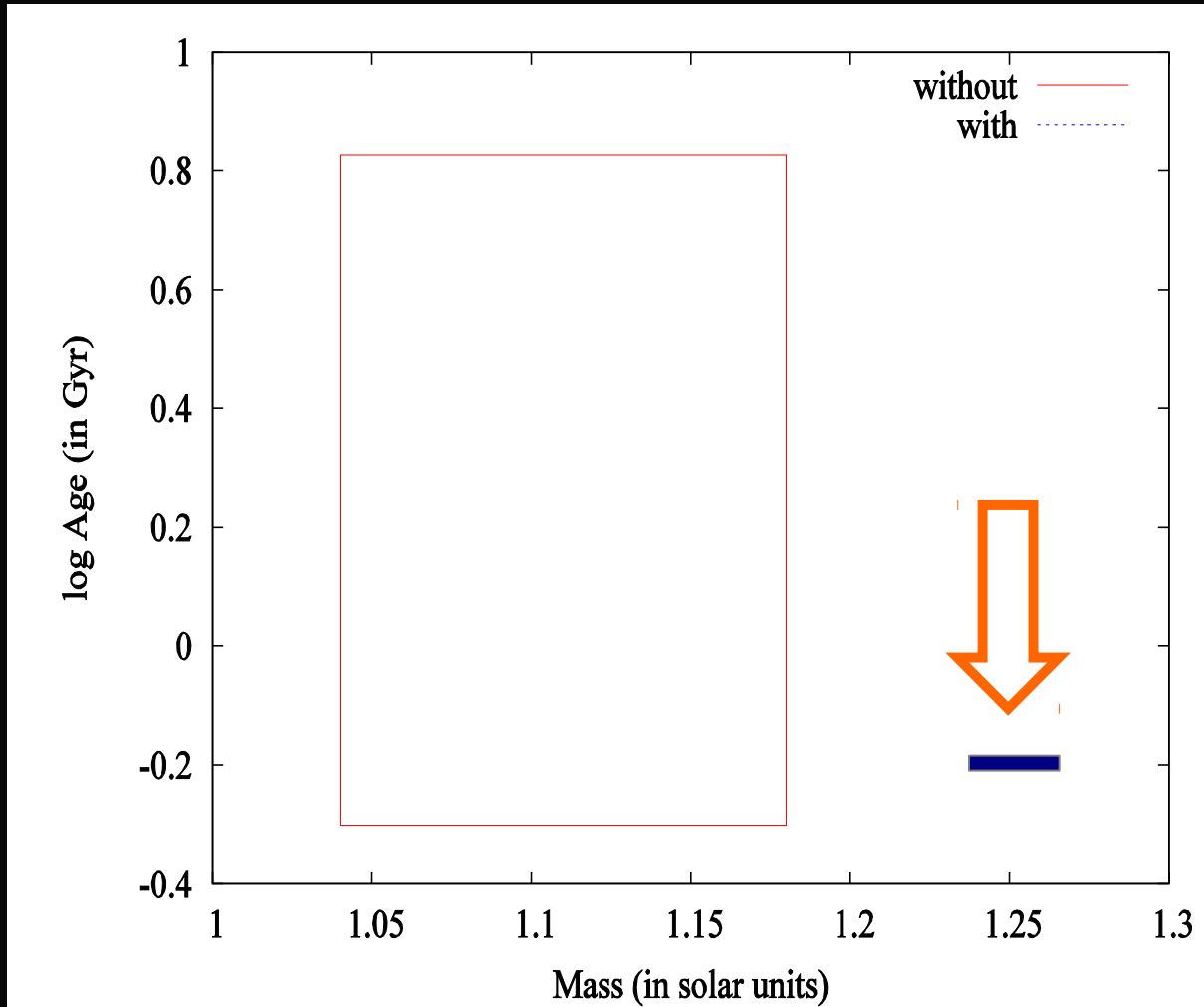


Fig. 2. The 422 frequencies extracted for HD 174936.

Time Series for everything

- Asteroseismology



Main conclusion:

Time series are important and should be published in the VO.

Use cases

Group B:

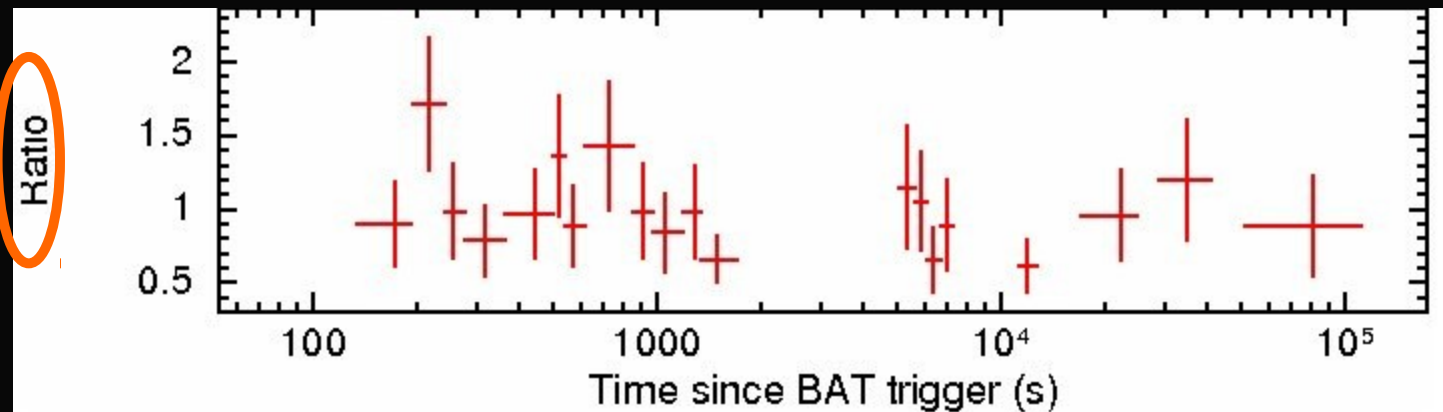
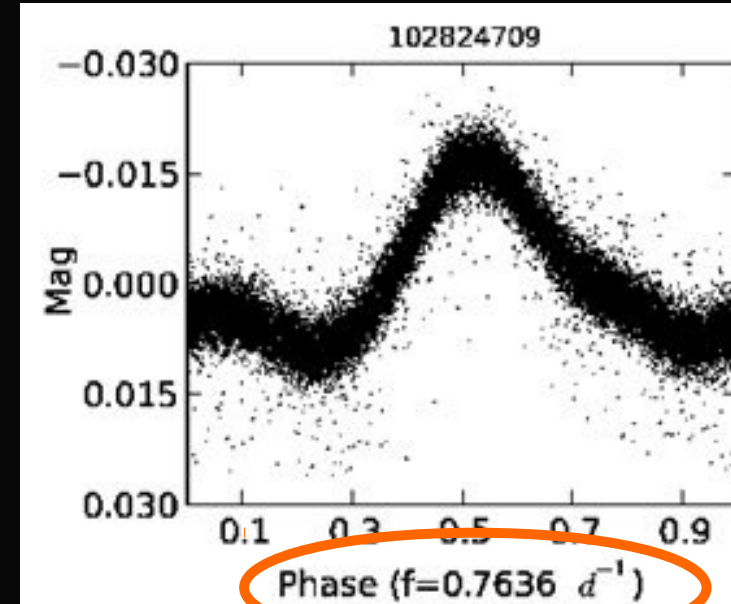
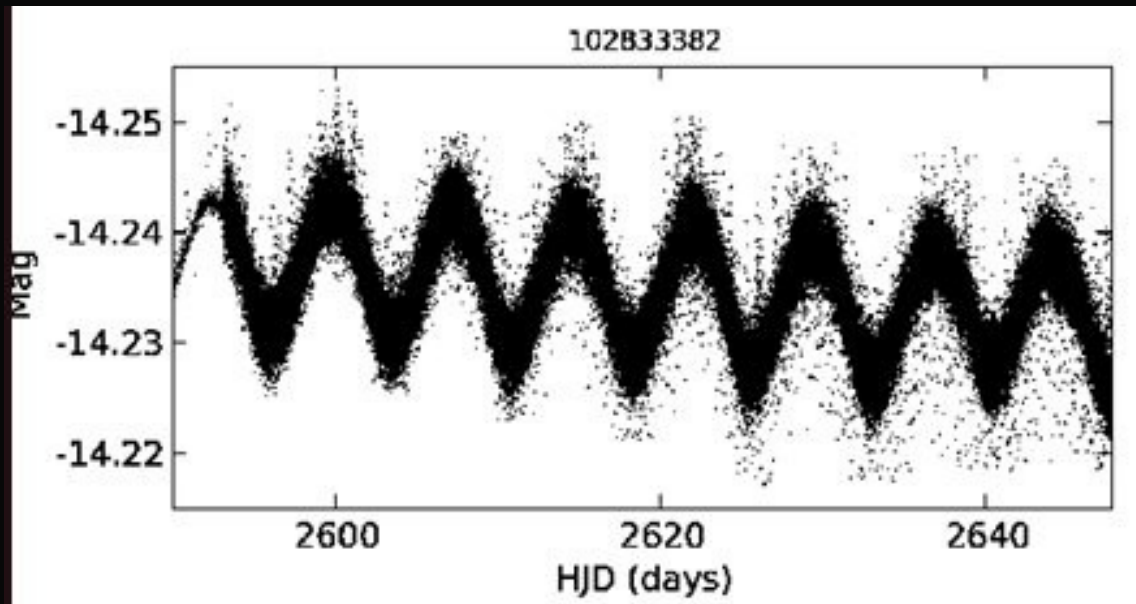
- **Common requirement: Combine photometry and light curves of a given object/list of objects in different photometric bands**
- Use Case #5: Follow-up characterisation of supernovae (based on Zhang et al. [arXiv:1208.6078v1](https://arxiv.org/abs/1208.6078v1))
 - Description: Light curves at different wavelength provide different information allowing a better understanding of the physical processes related to the supernovae explosion.
 - Requirements
 - Combine photometry and light curves of a given object in the same photometric band. Repeat this for all the available bands.
 - Show me a list of data that satisfies
 - Target= SN 2010JL
 - Datatype= Photometry or [TimeSeries](#)/lightcurves
 - Axes include time
 - Axes include brightness
 - Information on photometric band (zero point, transmission curve of the filter)

Group C:

- **Common requirement: Time series other than light curves**

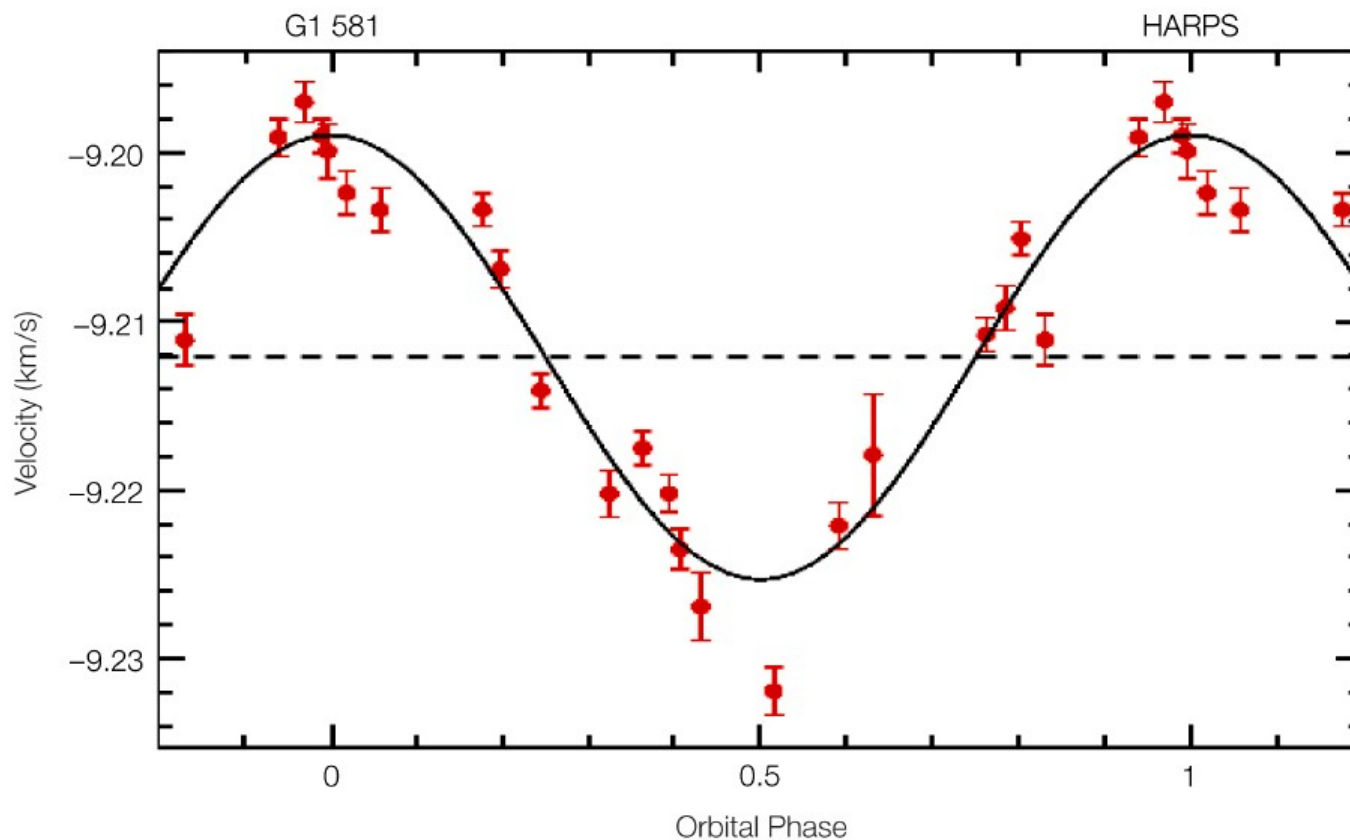
Use cases

- No canonical representation for Time Series



Use cases

- No canonical representation for Time Series



VO standards and Time Series

Science

Tools

Std

Session #2: Future of Data Discovery - Tuesday 16:30 - 18:00

topic	speaker	time
Time Series in the VO	Raul Gutierrez Sanchez	15 min

Data discovery	•Registry
Data access	•SSAP •IVOA note on 'Time Series Data' (Dec 2010) •ConeSearch •TAP
Data model	•SDM •SDM 2.0 •.Astro SimpleTimeseries •IVOA note on 'Time Series Data' (Dec 2010)

VO tools and Time Series

Science

Tools

Stds



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VAO Time Series Tool

Introduction

Discover time series data sets at the [Harvard Time Series Center \(TSC\)](#), the [NASA Exoplanet Archive](#) at IPAC/Caltech, and the [Catalina Real-Time Transient Survey](#) at CACR/Caltech, and analyze them with the NASA Exoplanet Archive's periodogram application.

This service is to a pathfinder for developing a utility that interconnects repositories of time series data. Please give us your feedback - it is important in driving future VO capabilities.

This service is recommended for use with the most recent versions of Firefox, Chrome or Safari. Internet Explorer 9, old versions of Firefox (prior to version 8) and Opera are not supported.

VAO Time Series Search

Use the fields below to enter a search location and radius.

Location:

Radius: arcsec

Summary

- ✓ Time Series are important.
- ✓ We (VO) are really late and we have to react fast.
 - ✓ The VO publication of (at least the simplest cases of) Time Series should be a reality soon.