Transient Astronomy with the Gaia Satellite

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The ESA Gaia mission

- 1 billion objects V=6-20 (~1% of the stars)
- Astrometry, Photometry, Spectrophotometry, Spectroscopy (radial velocities)
- 5 (+1) years (70x all sky): final results 2020-2021

http://www.rssd.esa.int/Gaia
Scanning Law

- Two telescopes, one focal plane
- Time between FOVs: $106.5\text{m}$
- Time between successive scans: $6\text{h}$
- Field revisited every $\sim30\text{ days}$
- Each object measured $\sim70\text{ times}$
- Densest coverage $\sim200\text{ epochs}$

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FoV: 0.7 deg x 0.7 deg
pixel: 0.059”(AL) x 0.177”(AC)

~1 billion pixels every 4.4 seconds.
Whole sky survey at very short time-scales
Photometry per transit

• 1% at $G=19$ (colours to $\sim10\%$)
• <2 mmag precision for $G<12$

• CCD TDI gates avoid pixel saturation for bright stars
Astrometry per transit

- OGA1: 50 milli arcsec (IDT)
- OGA2: 100 micro arcsec (24hr later)
BP/RP spectra:
classification

- two low-res fused-silica prisms
- BP 330-680nm @ 4-32 nm/pixel
- RP 640-1000nm @ 7-15 nm/pixel
Timeline for Data Flow

one operational day

8h visibility

backlog real time

acquisition Gaia

transmission MOC

transmission SOC

Initial Data Treatment

First Look

Astrometry (50 mas)

Astrometry (100 μas)

Science Alerts (Cambridge)

Figure courtesy Francois Mignard, updated by LW+STH

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New windows on transients across the universe, April 23-24 2012, Royal Society
SNa discovery rates

See also: Supernovae and Gaia, Altavilla et al. 2011, 2012Ap&SS.tmp...66A

http://www.cbat.eps.harvard.edu/lists/Supernovae.html
BP/RP SN Spectra: Parameter Estimation

- Input 1a templates (Nugent, Hsiao)
- Perturb spectra (magnitude, redshift) and add noise.
- Classify

Nadejda Blagorodnova, PhD @ IoA
BP/RP SN Spectra: Classification of Type

- Range of model templates (Nugent, Hsiao)
- Perturb spectra (magnitude, redshift), add noise.
- Classify

Confusion among SNIIp and IIL.

- Very similar spectra.
- Main differences in lightcurve.

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Astrometric microlensing

- Combine astrometric and photometric events to solve for the lens mass.
- Discovery of astrometric Black Hole and Brown Dwarf lensing events would be a significant first for Gaia.
- BH events will cause astrometric signals around 2 milliarcsec (distance dependent). BD events are an order of magnitude smaller.

Simulation from Lukasz Wyrzykowski: $ds=8.6\,kpc$, $dl=1\,kpc$, $ml=6\,m\text{sun}$
Watch List

• Known variables will typically be excluded from a transient survey.

• So we will be monitoring a pre-decided set of known interesting objects.

• Flexible - add an object to the list of alerts during the mission.

• Normally detected alerts will end-up in the Watch List.

• Real power will come from comparing with other surveys
Gaia Operations: Year 1

• Regular operations after 3 months accumulation + 3 months verification

• Verification/building a training set with a network of follow-up telescopes operating in Target of Opportunity (ToO) mode.
  - Good opportunity to get involved at early stage
  - All volunteering telescopes are very welcome!
Alert dissemination

• Publication of Alerts to the entire community: no proprietary data.

• VOEvent - machine-readable format, can be displayed in e.g. Google Sky

• Skyalert.org - will host both alerts and follow-up data
Welcome to the web site of the Gaia Science Alerts Working Group!

The Gaia-Alerts Working Group is focused on the real-time detection of variable sources. These include supernovae, microlensing events, exploding and eruptive stars, etc.

Everyone interested in the subject is invited to contribute to this website!

This page is maintained by Lukasz Wyrzykowski. Contact me for the password.


http://www.ast.cam.ac.uk/ioa/research/gsawg/
Summary

• Gaia will provide a rich source of transient phenomena

• the alert stream is non-proprietary and will be the first data from Gaia

• the science alerts software framework is in place (detection, curation, reporting)

• algorithm development ongoing - especially testing and refining our early classification schemes

• testing involves simulated and real data (e.g. SDSS, OGLE)

• plenty of scope for involvement