(Nuclear) Transient detection/characterisation with Gaia

Gaia Science Alerts workshop, 11th November 2015

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Nuclear Supernovae

- Lack of CCSN in central regions:
  - Different IMF?
  - Intrinsically fainter?
  - Dust?
  - Metallicity?
  - Bias in ground-based surveys?

Shaw effect

Hakobyan et al., 2008
Tidal Disruption

SMBH population for non-active galaxies: mass, spin

Accretion disk geometry in SMBH
Gaia parameter space

Original diagram in Kasliwal et al, 2011

Limiting mag: 20.5 mag
Cadence: ~35d
Background estimation:
- 5th lowest value of 16 samples

Flux estimation:
- Central 3x3 - background

Source detection:
- Flux
- Geometry 3x3 window

Details in De Bruijne et. al. 2015
The catalogue...

Historic transits

New Scans

New transits

Match radius

SOURCE

Measurements for each transit

<table>
<thead>
<tr>
<th>SM</th>
<th>AF 1</th>
<th>AF 2</th>
<th>AF 3</th>
<th>AF 4</th>
<th>AF 5</th>
<th>AF 6</th>
<th>AF 7</th>
<th>AF 8</th>
<th>AF 9</th>
</tr>
</thead>
</table>

Normalized response (energy)

\[ \lambda \text{[nm]} \]

50M day\(^{-1}\)

Historic Scans

New transits
GIBIS: Gaia Instrument and Basic Image Simulator

Simulation parameters:
- Bulge mag
- Bulge radius
- SN mag
- Angular separation
1.3M from SDSS mag< 20

~25% galaxies detected
What galaxies are detected?

Redshift

Blue cloud Red sequence

Detection probability

u - r

Model
% resolved in function of magnitude difference bulge-SN

Simulation for bulges with Re=1 arcsec

Blagorodnova et. al. 2015
Expected number of SNe. Limiting Magnitude=19

Orphan in Gaia:
75% SN Ia
90% CCSN

Blagorodnova et. al. 2015
TDE vs. SN - nuclear case

$m_{\text{lim}} = 19\text{mag}, \Delta m = 0.5\text{mag}$

Detected TDE $\sim$ Detected unresolved SN

$\rightarrow$ Low contamination!
No noticeable decrease in the number of detections close to nucleus.

Hakobyan et. al, 2008

Blagorodnova et. al. 2015
SN epoch at discovery

Existing low resolution spectra for classification!
Gaia Transient Classification

SNIa templates from Hsiao et al. 2007
GSTEC-Gaia Spectrophotometry
Transient Event Classifier

\[ P(M|D, m_G, v) = \frac{P(D, m_G, v|M)P(M)}{\int P(D, m_G, v|M)P(M)\,dM} \]

Blagorodnova et. al. 2014
Confusion Matrix for G=18mag.
21.33% unclassified (BB or Ambig)
90.05% of true positives in classified

<table>
<thead>
<tr>
<th></th>
<th>STAR (113.0)</th>
<th>SN Ibc (74.0)</th>
<th>SN Ia (208.0)</th>
<th>SN IIn (39.0)</th>
<th>SN IIP (77.0)</th>
<th>BB (0.0)</th>
<th>Ambig (0.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAR</td>
<td>94.0 (83.2%)</td>
<td>0.0</td>
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<tr>
<td>SN Ibc</td>
<td>8.0 (10.8%)</td>
<td>49.0 (66.2%)</td>
<td>1.0 (1.4%)</td>
<td>1.0 (1.4%)</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>SN Ia</td>
<td>0.0</td>
<td>0.0</td>
<td>169.0 (81.3%)</td>
<td>1.0 (0.5%)</td>
<td>0.0</td>
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<tr>
<td>SN IIn</td>
<td>3.0 (1.4%)</td>
<td>2.0 (5.1%)</td>
<td>0.0</td>
<td>13.0 (33.3%)</td>
<td>5.0 (12.8%)</td>
<td>6.0</td>
<td>13.0 (33.3%)</td>
</tr>
<tr>
<td>SN IIP</td>
<td>5.0 (6.5%)</td>
<td>3.0 (3.9%)</td>
<td>1.0 (1.3%)</td>
<td>7.0 (9.1%)</td>
<td>37.0 (48.1%)</td>
<td>3.0</td>
<td>21.0 (27.3%)</td>
</tr>
<tr>
<td>BB</td>
<td>0.0</td>
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90.05% of true positives in classified.
First Gaia SN BP/RP classification!

Identification of the first Gaia SN as SN Ia at z=0.03!

Best fit model:
SN Ia, 2 ± 8 days, z=0.03 ± 0.01

Confirmed from ground!
Gaia Alerts (so far)
- 275 published alerts until June 2015
- 98 spectroscopically confirmed SN
Gaia Alerts (so far)

- SN Ia (64): 64.9%
- SN II (28): 28.4%
- SN Ibc (6): 6.8%

<1 arcsec?
On-board parameters

De Bruijne et al., 2015

http://www.cosmos.esa.int/web/gaia/iow_20150409

http://www.cosmos.esa.int/web/gaia/iow_20141205
Validation phase and improvements
Dream... watch-list?

The Astronomer’s Telegram

Mag

VOEvent

Time

Mag
Conclusions

- **Gaia is a** suitable tool for high-accuracy measurements of slow-rising transients.

  - FREE low-resolution classification.

  - Observations close to the Sun.

  - Observations on low-profile days.

- Change in on-board detection parameters has increased the number of “fake” detections.

- **Currently**, changes in pipeline focus on cleaning the sample and approaching the nucleus!
Gaia DPAC

&

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Thank you!