Gamma-rays from classical novae: expectations from present and future missions
Margarita Hernanz (IEEC/CSIC, Barcelona, Spain)

Outline

• Radioactive isotopes produced in nova explosions
• Gamma-ray signatures of novae: lines and continuum
• Observational status and prospects for detectability of individual novae: past, present and future
• Other signatures of radioactivity in novae: presolar grains
• Summary
Scenario

Mass transfer from the companion star onto the white dwarf (cataclysmic variable)

Hydrogen burning in degenerate conditions on top of the white dwarf

Thermonuclear runaway

Explosive H-burning

Decay of short-lived radioactive nuclei in the outer envelope (transported by convection)

Envelope expansion, L increase and mass ejection
## Main radioactive isotopes synthesized in classical novae

<table>
<thead>
<tr>
<th>Nucleus</th>
<th>$\tau$</th>
<th>Type of emission</th>
<th>Nova type</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{13}\text{N}$</td>
<td>862 s</td>
<td>511 keV line, continuum (E&lt;511 keV)</td>
<td>CO and ONe</td>
</tr>
<tr>
<td>$^{18}\text{F}$</td>
<td>158 min</td>
<td>511 keV line, continuum (E&lt;511 keV)</td>
<td>CO and ONe</td>
</tr>
<tr>
<td>$^{7}\text{Be}$</td>
<td>77 days</td>
<td>478 keV line</td>
<td>CO mainly</td>
</tr>
<tr>
<td>$^{22}\text{Na}$</td>
<td>3.75 yr</td>
<td>1275 keV line</td>
<td>ONe</td>
</tr>
<tr>
<td>$^{26}\text{Al}$</td>
<td>1.0X10$^6$ yr</td>
<td>1809 keV line</td>
<td>ONe</td>
</tr>
</tbody>
</table>
Spectra of CO novae

\[ M_{WD} = 1.15 \, M_\odot \]

- \( e^- - e^+ \) annihilation and Comptonization continuum and 511 keV line; \( e^+ \) from \( ^{13}\text{N} \) and \( ^{18}\text{F} \) predicted theoretically by Clayton & Hoyle 1974; Leising & Clayton 1987

- Photoelectric absorption cutoff at 20 keV
- 478 keV line from \( ^7\text{Be} \) decay
- Transparent at 48 h

Spectra of CO novae

- lower fluxes
- longer duration: at 48 h there is still continuum and 511 keV line emission
- larger opacities of the expanding shells than in $1.15 \, M_{\odot}$

$M_{WD} = 0.8 \, M_{\odot}$
Spectra of ONe novae

- Photoelectric absorption cutoff at 30 keV
- Continuum and 511 keV as in CO novae
- 1275 keV line from $^{22}\text{Na}$ decay
- Similar behaviour for the 2 models, because of similar KE and yields

$M_{WD} = 1.15 \, M_\odot$ (solid)
$1.25 \, M_\odot$ (dotted)
Light curves: 1275 keV ($^{22}$Na) line

Rise phase

$t_{\text{max}}$: 20 days ($1.15\,M_\odot$), 12 days ($1.25\,M_\odot$), line width $\sim 20$ keV

duration: some months

Flux $\sim 2\times 10^{-5}$ ph/cm$^2$/s

Only in ONe novae

d=1 kpc

Exponential decline

predicted theoretically by Clayton & Hoyle, 1974
Observations: 1275 keV line ($^{22}$Na)

Fig. 1. Sum of residual spectra of Nova Her 1991 for the viewing periods 7.5, 13.0, 20 and 231. Statistical 1 $\sigma$ error bars are shown. The dashed line represents the expected $^{22}$Na line appearance according to the ejecta mass derived by Woodward et al. 1992, with a $^{22}$Na mass fraction of model 3 of Starrfield et al. 1992. This signal would have been seen by COMPTEL at the significance level of $\sim 8\,\sigma$.

Fig. 2. Sum of the background-subtracted spectra of Nova Cyg 1992 for the viewing periods 34, 203 and 212. Statistical error bars are shown. The dashed line represents the expected $^{22}$Na line appearance according to the predictions of Starrfield et al. 1992. This signal would have been seen by COMPTEL at the significance level of $\sim 17\,\sigma$.

CGRO/COMPTEL: no detection; upper limits

Iyudin et al. 1995, A&A
Observations: 1275 keV line (\(^{22}\text{Na}\))

CGRO/COMPTEL upper limits in agreement with current theoretical predictions

<table>
<thead>
<tr>
<th>Nova name</th>
<th>Galactic l</th>
<th>Galactic b</th>
<th>Date of max m_ν</th>
<th>Nova type</th>
<th>2 σ up. lim. ph./(cm^2s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cen 1991</td>
<td>309.5°</td>
<td>-1.04°</td>
<td>17-Mar-91</td>
<td>stand.</td>
<td>4.0E-05</td>
</tr>
<tr>
<td>Her 1991</td>
<td>43.3°</td>
<td>6.6°</td>
<td>24-Mar-91</td>
<td>neon</td>
<td>3.3E-05</td>
</tr>
<tr>
<td>Sgr 1991</td>
<td>0.18°</td>
<td>-6.94°</td>
<td>29-Jul-91</td>
<td>neon</td>
<td>6.2E-05</td>
</tr>
<tr>
<td>Sct 1991</td>
<td>25.1°</td>
<td>-2.80°</td>
<td>08-Aug-91</td>
<td>neon</td>
<td>3.6E-05</td>
</tr>
<tr>
<td>Pup 1991</td>
<td>252.7°</td>
<td>-0.72°</td>
<td>27-Dec-91</td>
<td>neon</td>
<td>5.5E-05</td>
</tr>
<tr>
<td>Cyg 1992</td>
<td>89.14°</td>
<td>7.82°</td>
<td>20-Feb-92</td>
<td>neon</td>
<td>2.3E-05</td>
</tr>
<tr>
<td>Sco 1992</td>
<td>343.8°</td>
<td>-1.61°</td>
<td>26-May-92</td>
<td>stand.</td>
<td>5.9E-05</td>
</tr>
<tr>
<td>Sgr 1992-1</td>
<td>4.75°</td>
<td>-2.0°</td>
<td>06-Feb-92</td>
<td>stand.</td>
<td>6.0E-05</td>
</tr>
<tr>
<td>Sgr 1992-2</td>
<td>4.56°</td>
<td>-6.96°</td>
<td>19-Jul-92</td>
<td>stand.</td>
<td>3.0E-05</td>
</tr>
<tr>
<td>Sgr 1992-3</td>
<td>9.38°</td>
<td>-4.54°</td>
<td>29-Sep-92</td>
<td>stand.</td>
<td>4.4E-05</td>
</tr>
<tr>
<td>Aql 1993</td>
<td>36.81°</td>
<td>-4.10°</td>
<td>17-May-93</td>
<td>stand.</td>
<td>6.2E-05</td>
</tr>
</tbody>
</table>

Table 2. List of the recent novae searched for the presence of \(^{22}\text{Na}\) line emission and the derived upper limits.

<table>
<thead>
<tr>
<th>Nova name</th>
<th>m_ν at max</th>
<th>M_ν at max</th>
<th>t_3 days</th>
<th>d kpc</th>
<th>2 σ up. limit to (^{22}\text{Na}) mass ej.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Her 1991</td>
<td>5.3</td>
<td>-9.5</td>
<td>4</td>
<td>3.4</td>
<td>1.2 \times 10^{-7} M_☉</td>
</tr>
<tr>
<td>Sgr 1991</td>
<td>\sim 7</td>
<td>-9.5</td>
<td>47</td>
<td>12.5</td>
<td>2.4 \times 10^{-6} M_☉</td>
</tr>
<tr>
<td>Sct 1991</td>
<td>10.5</td>
<td>-8.9</td>
<td>10</td>
<td>12</td>
<td>2.0 \times 10^{-6} M_☉</td>
</tr>
<tr>
<td>Pup 1991</td>
<td>6.4</td>
<td>-8.5</td>
<td>26</td>
<td>3.5</td>
<td>1.5 \times 10^{-7} M_☉</td>
</tr>
<tr>
<td>Cyg 1992</td>
<td>4.4</td>
<td>-7.6</td>
<td>47</td>
<td>2.3</td>
<td>3.0 \times 10^{-8} M_☉</td>
</tr>
</tbody>
</table>

Table 3. COMPTEL limits on the ejected \(^{22}\text{Na}\) mass from recent novae.

Lyudin et al. 1995, A&A
### Theoretical predictions: \(^{22}\)Na ejected masses by ONe novae

<table>
<thead>
<tr>
<th>WD mass</th>
<th>Minimum</th>
<th>Best</th>
<th>Maximum*</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.15</td>
<td>3.1 \times 10^{-9}</td>
<td>7.0 \times 10^{-9}</td>
<td>1.4 \times 10^{-8}</td>
<td>4.5</td>
</tr>
<tr>
<td>1.25</td>
<td>3.4 \times 10^{-9}</td>
<td>6.3 \times 10^{-9}</td>
<td>1.2 \times 10^{-8}</td>
<td>3.5</td>
</tr>
<tr>
<td>1.35</td>
<td>3.4 \times 10^{-9}</td>
<td>4.4 \times 10^{-9}</td>
<td>6.2 \times 10^{-9}</td>
<td>1.8</td>
</tr>
</tbody>
</table>

(all in \(M_\odot\))  

*Coc and Smirnova 2000, Phys.Rev. C: smaller Max/Min*
Light curves: 478 keV ($^7$Be) line

Only in CO novae

$t_{\text{max}}$: 13 days (0.8$M_\odot$)

5 days (1.15 $M_\odot$)

duration: some weeks

Flux $\sim (1-2) \times 10^{-6}$ ph/cm$^2$/s

Line width: 3-7 keV

d=1 kpc

predicted theoretically by Clayton 1981
Observations: 478 keV line (\(^{7}\text{Be}\))

**RESULTS FOR 478 keV LINE FLUXES AND \(^{7}\text{Be}\) YIELDS**

<table>
<thead>
<tr>
<th>TARGET</th>
<th>DISTANCE(^a) (pc)</th>
<th>ZENITH ANGLE (deg)</th>
<th>FLUX ((\gamma \text{ cm}^{-2} \text{ s}^{-1}))</th>
<th>IMPLIED (^{7}\text{Be}) MASS(^b) ((M_{\odot}) per Nova)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Observed(^b)</td>
<td>Expected(^c)</td>
</tr>
<tr>
<td>Undiscovered nova</td>
<td></td>
<td></td>
<td>1.0 \times 10^{-4}</td>
<td></td>
</tr>
<tr>
<td>BY Cir</td>
<td>3160</td>
<td>60</td>
<td>6.8 \times 10^{-5}</td>
<td>1.1 \times 10^{-5}</td>
</tr>
<tr>
<td>V888 Cen</td>
<td>4800</td>
<td>42</td>
<td>6.3 \times 10^{-5}</td>
<td>4.9 \times 10^{-6}</td>
</tr>
<tr>
<td>V4361 Sgr</td>
<td>6700</td>
<td>95</td>
<td>1.1 \times 10^{-4}</td>
<td>2.5 \times 10^{-6}</td>
</tr>
<tr>
<td>CP Cru</td>
<td>3180(^d)</td>
<td>37</td>
<td>8.8 \times 10^{-5}</td>
<td>2.2 \times 10^{-6}</td>
</tr>
<tr>
<td>V1141 Sco</td>
<td>6120</td>
<td>97</td>
<td>1.6 \times 10^{-4}</td>
<td>3.0 \times 10^{-6}</td>
</tr>
<tr>
<td>V1370 Aql(^e)</td>
<td>3500</td>
<td></td>
<td>1.2 \times 10^{-3}</td>
<td>1.8 \times 10^{-6}</td>
</tr>
<tr>
<td>QU Vul(^e)</td>
<td>3000</td>
<td></td>
<td>7.5 \times 10^{-4}</td>
<td>2.5 \times 10^{-6}</td>
</tr>
<tr>
<td>V842 Cen(^e)</td>
<td>1100</td>
<td></td>
<td>9.6 \times 10^{-4}</td>
<td>9.3 \times 10^{-5}</td>
</tr>
<tr>
<td><strong>GC Integrated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TGRS</td>
<td>8000</td>
<td>84.5</td>
<td>7.7 \times 10^{-5}</td>
<td>7.8R_N \times 10^{-8}</td>
</tr>
<tr>
<td>SMM</td>
<td>8000</td>
<td></td>
<td>1.5 \times 10^{-4}</td>
<td>1.6R_N \times 10^{-7}</td>
</tr>
</tbody>
</table>

Upper limits from Harris et al. 1991 and 2001 in agreement with current theoretical predictions
Theoretical predictions: $^7\text{Be}$ ejected masses by novae

<table>
<thead>
<tr>
<th>WD mass</th>
<th>Nova type</th>
<th>Ejected mass of $^7\text{Be}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>C O</td>
<td>$6.0 \cdot 10^{-11}$</td>
</tr>
<tr>
<td>1.15</td>
<td>C O</td>
<td>$1.1 \cdot 10^{-10}$</td>
</tr>
<tr>
<td>1.15</td>
<td>O Ne</td>
<td>$1.6 \cdot 10^{-11}$</td>
</tr>
<tr>
<td>1.25</td>
<td>O Ne</td>
<td>$1.2 \cdot 10^{-11}$</td>
</tr>
</tbody>
</table>

(in $M_\odot$)
Observations with INTEGRAL/SPI

### 3σ detectability distances (kpc)

<table>
<thead>
<tr>
<th>Model</th>
<th>$M_{WD}(M_\odot)$</th>
<th>511 keV line</th>
<th>478 keV line</th>
<th>1275 keV line</th>
<th>continuum*(170-470 keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0.8</td>
<td>0.7</td>
<td>0.4</td>
<td>-</td>
<td>0.4</td>
</tr>
<tr>
<td>CO</td>
<td>1.15</td>
<td>2.4</td>
<td>0.5</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>ONe</td>
<td>1.15</td>
<td>3.7</td>
<td>-</td>
<td>1.1</td>
<td>3.0</td>
</tr>
<tr>
<td>ONe</td>
<td>1.25</td>
<td>4.3</td>
<td>-</td>
<td>1.1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Width of the lines fully taken into account

Future missions: MAX, MEGA, ACT, LXeTPC ...
Novae distances (observed)


1275 keV: $d < (1-2)\text{kpc}$ $\rightarrow (1-3)/(5 \text{ yr})$
Light curves: 511 keV line

In CO and ONe novae

<table>
<thead>
<tr>
<th>Model</th>
<th>$t_{\text{max}}^*$ (h)</th>
<th>$F_{\text{max}}$ (ph/cm²/s) **</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO, 0.8 M$_\odot$</td>
<td>- - -</td>
<td>$2.6 \times 10^{-5}$</td>
</tr>
<tr>
<td>CO, 1.15 M$_\odot$</td>
<td>6.5</td>
<td>$5.3 \times 10^{-4}$</td>
</tr>
<tr>
<td>ONe, 1.15 M$_\odot$</td>
<td>6</td>
<td>$1.0 \times 10^{-3}$</td>
</tr>
<tr>
<td>ONe, 1.25 M$_\odot$</td>
<td>5</td>
<td>$1.9 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

- 511 keV line in ONe novae remains after 2 days until ~ 1 week because of $e^+$ from $^{22}\text{Na}$
- Intense (but short duration)
- Very early appearance, before visual maximum (i.e., before discovery)
Line profiles: 511 keV line

CO nova

$M_{WD} = 1.15 \ M_\odot$

d=1 kpc

The line is blueshifted, until the envelope reaches transparency:

518 keV (1h) 512 keV (24h)

FWHM (12h) = 7 keV
Gamma-ray and visual light curves

Visual maximum later than 511 keV and continuum maxima
The continuum and the 511 keV line, $e^-e^+$ annihilation, are the most intense emissions, but their duration is very short and they appear before visual discovery.

Detection requires “a posteriori” analyses with wide FOV instruments (BATSE, TGRS, RHESSI).

Future hard X/soft $\gamma$-ray surveys like EXIST can provide unique information about the Galactic nova distribution.
Observations: 511 keV line

**WIND/TGRS:** no detection; upper limits

### Upper Limits on 511 keV Line Emission from Novae

<table>
<thead>
<tr>
<th>Nova</th>
<th>Angle of Incidence</th>
<th>Mean 3 $\sigma$ Upper Limit in 6 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nova Cir 1995……</td>
<td>44.9</td>
<td>$2.2 \times 10^{-3}$</td>
</tr>
<tr>
<td>Nova Cen 1995……</td>
<td>42.0</td>
<td>$2.0 \times 10^{-3}$</td>
</tr>
<tr>
<td>Nova Sgr 1996……</td>
<td>95.2</td>
<td>$2.8 \times 10^{-3}$</td>
</tr>
<tr>
<td>Nova Cru 1996……</td>
<td>36.9</td>
<td>$2.3 \times 10^{-3}$</td>
</tr>
<tr>
<td>Nova Sco 1997……</td>
<td>83.4</td>
<td>$2.9 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

- Observation of 5 known Galactic novae in the broad TGRS FOV in the period **1995 Jan - 1997 June**

- High E-resolution **Ge detector:** ability to detect 511 keV line blueshifted w.r.t. background line

WIND/TGRS: “constraining” the Galactic nova rate from a survey of the Southern Sky during 1995-1997

From the non detection, an upper limit of the Galactic nova rate was extracted:

- $< 123 \text{ yr}^{-1}$ (CO novae; $r_{\text{detect.}} = 0.9 \text{ kpc}$)
- $< 238 \text{ yr}^{-1}$ (ONe novae; $r_{\text{detect.}} = 0.7 \text{ kpc}$)

Promising for future wide FOV instruments sensitive in the soft $\gamma$-ray range (20-511) keV

Observations: 511 keV line

CGRO/BATSE

List of nearby novae (d < 3-4 kpc) since CGRO launch

<table>
<thead>
<tr>
<th></th>
<th>Pup91</th>
<th>Sgr92#1</th>
<th>Cyg92</th>
<th>Sco92</th>
<th>Cas93</th>
<th>Aql95</th>
<th>Cir95</th>
<th>Vel99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of discovery</td>
<td>Dec 27</td>
<td>Feb 13</td>
<td>Feb 19</td>
<td>May 26</td>
<td>Dec 8</td>
<td>Feb 7</td>
<td>Jan 27</td>
<td>May 22</td>
</tr>
<tr>
<td>$m_v$ (max.)</td>
<td>6.4</td>
<td>7.3</td>
<td>4.2</td>
<td>7.3</td>
<td>5.3</td>
<td>8.1</td>
<td>7.2</td>
<td>2.8</td>
</tr>
<tr>
<td>$t_2$ (d)</td>
<td>15</td>
<td>4-14</td>
<td>16</td>
<td>73</td>
<td>33</td>
<td>11</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>$d$ (kpc)</td>
<td>2.9</td>
<td>3.6</td>
<td>1.7</td>
<td>0.8</td>
<td>2.8</td>
<td>1.9</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>


Other candidate novae: Cru96, Sco97, Sgr98, Oph98, Sco98, Mus98


Smith, Hernanz et al. 2003, in preparation
EXIST (Energetic X-ray Imaging Survey Telecope)

Mission Parameters (low -- high energy)

Energy range (resolution): 10-100 (1) keV; 100 - 600 (3) keV

FOV & angular resolution: 180° x 75°; 5'
central-field for pointing: 5° x 5°; 50° x 40°

Sensitivity (5σ):
2mCrab --> 20mCrab/orbit
(0.05mCrab=5x10^-13cgs)
0.05mCrab --> 0.5mCrab/year

From EXIST WEB page:
EXIST.gsfc.nasa.gov

Continuum and line sensitivities (3σ)
(~6-12mo. Survey; dep. on orb. lat.)
Light curves: annihilation continuum

**CO Nova, 0.8 M☉**

- **13N**
- Light curves with ΔE=E
  - solid: (30–90) keV
  - dotted: (25–75) keV
  - dashed: (20–60) keV

**CO Nova, 1.15 M☉**

- **13N**
- Light curves with ΔE=E
  - solid: (30–90) keV
  - dotted: (25–75) keV
  - dashed: (20–60) keV

**18F**
Detectability of annihilation continuum vs. starting observation time

CO Nova, 0.8 \(M_\odot\)

- \(d=12\) kpc \(\Rightarrow N_{th}>30\) yr\(^{-1}\)
- \(d=2\) kpc \(\Rightarrow N_{th}\sim0.5\) yr\(^{-1}\)

EXIST sensitivity per orbit
Detectability of annihilation continuum vs. starting observation time

CO Nova, 1.15 $M_{\odot}$

EXIST sensitivity per orbit

$\text{d}=15\text{kpc} \quad N_{\text{th}}>30\text{yr}^{-1}$

$\text{d}=5\text{kpc} \quad N_{\text{th}}\sim 3\text{yr}^{-1}$
Light curves: annihilation continuum

**ONe Nova, 1.15 M☉**

- Light curves with $\Delta E = E$
- Solid: (30–90) keV
- Dotted: (25–75) keV
- Dashed: (20–60) keV

**ONe Nova, 1.25 M☉**

- Light curves with $\Delta E = E$
- Solid: (30–90) keV
- Dotted: (25–75) keV
- Dashed: (20–60) keV
Detectability of annihilation continuum vs. starting observation time

ONe Nova, 1.15 $M_\odot$

ONe Nova, 1.25 $M_\odot$

EXIST sensitivity per orbit

d=3 kpc $\Rightarrow$ $N_{th} \sim 1\text{yr}^{-1}$

d=4 kpc $\Rightarrow$ $N_{th} \sim 2\text{yr}^{-1}$

ONe nova $M=1.15M_\odot$

solid: (30–90) keV

dotted: (25–75) keV

dashed: (20–60) keV

ONe nova $M=1.25M_\odot$

solid: (30–90) keV

dotted: (25–75) keV

dashed: (20–60) keV

Detection distance (kpc)

Time (hours)
Novae rates vs. distance (theoretical)

**EXIST detectability distances (contin.)**

- **CO novae:** $d \sim (2,3-12,15)$ kpc $\rightarrow (0.5,1-30)/yr$
- **ONe novae:** $d \sim (3-4)$ kpc $\rightarrow (1-2)/yr$

**Fig. from Pierre Jean**
Novae distances (observed)

Distances from

EXIST detectability distances (contin.)

CO novae: $d \sim (2.3-12.15)$ kpc $\rightarrow (3.6-21)/(5 \text{ yr})$

ONe novae: $d\sim (3-4)$ kpc $\rightarrow (6-9)/(5 \text{ yr})$
Nuclear uncertainties related with $^{18}\text{F}$ synthesis (511 keV & continuum emission)

Rates obtained including the latest experimental data up to the end of 1999

Coc, Hernanz, José, Thibaud, 2002, A&A
Nuclear uncertainties related with 18F synthesis (511 keV & continuum emission)

Recent experimental determination of the $^{18}\text{F}(p,\alpha)^{15}\text{O}$ reaction rate
de Séreville, Coc, Angulo et al. 2003, Phys. Rev. C: reduction of the uncertainty and nominal rate similar

Good news!

(see talk by Angulo)
Other signatures of radioactivities in novae: presolar grains

five SiC and one graphite grain from the Murchison meteorite show isotopic compositions indicating a nova origin
Other signatures of radioactivities in novae: presolar grains
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Summary

- Classical novae produce gamma-rays:
  - CO novae: continuum $20 \leq E \leq 511$ keV; lines at 511 keV and 478 keV
  - ONe novae: continuum $20 \leq E \leq 511$ keV; lines at 511 keV and 1275 keV

- The continuum and the 511 keV line are the most intense emissions, but their duration is very short and they appear before visual discovery
  - Detection requires “a posteriori” analyses with wide FOV instruments (BATSE, TGRS)

- Future gamma-ray surveys like EXIST can provide unique information about the Galactic nova distribution:
  - CO novae: $d \sim (2.3-12.15)$ kpc  $N_{\text{theor}} \sim (0.5, 1-30)/yr$
  - ONe novae: $d \sim (3-4)$ kpc  $N_{\text{theor}} \sim (1-2)/yr$

  $N_{\text{tot}}$ observed per year: $\sim 3-5 << N_{\text{tot}}$ predicted per year: $(35\pm 11)/yr$,
  because of visual extinction