Isomers in LISE++

* Introduction
* GANIL isomer database in LISE++
* LISE internal isomer database
* \(\gamma\)-detector efficiency
* Rate calculation of isomer \(\gamma\)-rays
* Isomeric \(\gamma\)-spectrum
* Identification 2D-plot in coincidence with \(\gamma\)-rays

Version 7.6.39 from 01/16/06 available through LISE sites
Fragment identification using isomeric $\gamma$-rays

How do we work now?

Experiment

$Z=47$

Internet database (NNDC)

region of stable isotopes

Old GANIL database available through LISE

Private communications

January 13 (Friday), 2006 – Separator Meeting

from 12/16/2005
LISE isomer database

LISE++ database (dbf-format)

Old GANIL database available through LISE

New experimental data
It will be nice to simulate…

Color identification plot of all nuclei observed (left panel) and those in correlation with gamma radiation (right panel). The \((A-2q)/2\) variable is equal to the \(T_Z\) of the nucleus for fully stripped ion \((q=Z)\). A symbol “\(96_{\text{m}}\text{Pd}^{45+}\)” denotes \(96_{\text{m}}\text{Pd}\) nuclei transmitted and detected as a hydrogen like ions.
Nuclei from $Z=1-50$. About 400 isomers.

Isomers which are referenced on this chart have a half-life greater than 10 ns. Three different codes of colors have been used in order to have information about the half-life of the isomeric states:

- for isomeric states with half life over 1 millisecond.
- for isomeric state with half life between 1 microsecond and 1 millisecond.
- for isomeric state with half life between 10 nanosecond and 1 microsecond.
Isomer Database in Internet

It is interactive!

Click on the chart to have the level scheme of the request isomer

Unfortunately there are not data tables which could be transformed in a database. Just level scheme pictures.
Information about the GANIL isomer database is kept in the “bin/isomers.txt” file. Fields are separated by comma. One Line per one nucleus. There are 3 fields to get a level scheme.

Example: 38cl, 21, 4
Web address: http://www.ganil.fr/lise/chart/chart/chart21/38cl.gif
First field: A El; Second field: Chart index (11-54)
Third field: half-life (4*Green + 2*Blue + 1*Yellow)
LISE++ isomer database

Selection from NNDC
- $Z, A$: no conditions
- $100 < E_{\text{level}} \text{ (keV)} < 10000$
- $100 < E_{\gamma_{\text{max}}} \text{ (keV)} < 4000$
- $1 \text{ ns} < T_{1/2} < 100 \mu$s

**Obligatory fields**
- $Z, A, E_{\gamma}$
- $I_{\gamma}, T_{1/2}, \text{ IT ratio}$

**User Name**

**Selection from NNDC**
- $NNDC$: 1752
- Bryan Tomlin's thesis 44
- Caamano, EPJA23 (2005) 201 40
- GANIL JM-database 13
- Daugas, PLB476(2000)213 4
- Robisnon, PRC53(1996)1465 1
- Grand Total (gamma-rays) 1854

**User Name**

LISE isomer database base (dBASE3 format) is kept initially in the "bin/isomers.dbf" file. All fields in "char" format.

Automatic record sorting in the database after "Add", "Delete" and "Save" commands. Index is recalculated automatically basing on $A, Z, E_{\gamma}$.

Database file size is about 360 kB. (in the LISE package)

Only users with administrative privileges can modify the database in the "Program files" directory.

There is the possibility of a net database version.

Use arrow buttons in the right bottom corner to change current isomeric gamma ray.
LISE++ isomer database location (v.7.6.39)

New tabulation field

Path to the LISE isomer database
LISE database limitation

Examples

- Cu neutron-rich isotopes
- $^{38}\text{K}$ isomer gamma rays
Gamma-ray yield is proportional to the number of implanted fragments in the telescope at the final focal plane. Reference gamma-rays are randomly distributed on time and on energy in region 0 – 4 MeV.

If $G$ is the number of gamma rays per implanted fragment then

$$R = \frac{G \times \text{Gate}}{4000} \text{ [1 / keV / sec]}$$
Calculation of $\gamma$–rays yield

Only for isomer states from the LISE internal isomer database

- $Y_{\gamma \text{ isomer}} = \text{Im ratio} \times I_{\gamma} \times Y_{\text{fragment}} \times \varepsilon_{\text{AcqGate}} \times \varepsilon_{\text{detect}}$

- $\varepsilon_{\text{AcqGate}}$ : probability to be in the $\gamma$– acquisition gate
  - $T_{1/2}$, Length of flight, Fragment Energy,
  - Gamma-acquisition delay and gate

- $\varepsilon_{\text{detect}}$ : detector efficiency
  - Geometrical efficiency or/and $f(E_\gamma)$

- A survival of fully stripped ions in flight is not taken into account for fully stripped ions
γ-rays yield calculation result

**Isomeric states:** gamma/frag=3.51e-07  IT=2.24e-04/s

<table>
<thead>
<tr>
<th>E_\text{gamma} [eV]</th>
<th>T12 [ns]</th>
<th>IT_{T1&amp;T2}</th>
<th>Eff</th>
<th>g_{AcqGate}</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.8</td>
<td>2.198e+01</td>
<td>1.0e-01</td>
<td>0.00e+00</td>
<td>2.68e-01</td>
<td>0.00e+00</td>
</tr>
<tr>
<td>811.9</td>
<td>2.198e+01</td>
<td>3.4e-02</td>
<td>1.32e-02</td>
<td>2.68e-01</td>
<td>1.20e-04</td>
</tr>
<tr>
<td>845.1</td>
<td>2.198e+01</td>
<td>4.0e-05</td>
<td>1.28e-02</td>
<td>2.68e-01</td>
<td>1.38e-07</td>
</tr>
<tr>
<td>1055.6</td>
<td>2.198e+01</td>
<td>6.0e-05</td>
<td>1.10e-02</td>
<td>2.68e-01</td>
<td>1.77e-07</td>
</tr>
<tr>
<td>1759.7</td>
<td>2.198e+01</td>
<td>6.0e-05</td>
<td>7.74e-03</td>
<td>2.68e-01</td>
<td>1.25e-07</td>
</tr>
<tr>
<td>2999.2</td>
<td>2.198e+01</td>
<td>7.0e-05</td>
<td>5.34e-03</td>
<td>2.68e-01</td>
<td>1.00e-07</td>
</tr>
<tr>
<td>3327.4</td>
<td>2.198e+01</td>
<td>8.0e-05</td>
<td>4.97e-03</td>
<td>2.68e-01</td>
<td>1.07e-07</td>
</tr>
<tr>
<td>3457.8</td>
<td>2.198e+01</td>
<td>2.7e-04</td>
<td>4.84e-03</td>
<td>2.68e-01</td>
<td>3.51e-07</td>
</tr>
</tbody>
</table>

**Production Rate (pps):** 6.4e+2

**Reaction:** Fragmentation

**Total Transmission:** 99.1%

**X Space Transmission:** 100%

**Y Space Transmission:** 100%

**Unreacted in Matter:** 99.1%

**Isomer (GANIL)**

Information about isomer gamma yield of given isotope in the Statistics window.
Isomeric γ-spectrum: $^{44}$Ca(80MeV/u, 1pnA) + Be(100µm)
Identification 2D-plot in coincidence with $\gamma$–rays

- It was done for both methods:
  - Monte Carlo
  - “ellipse” mode

a. $Y_{\text{frag}}(A, Z)$

b. $Y_{\gamma_{\text{isomer}}}(A, Z) = Y_{\text{frag}}(A, Z) \cdot \sum P_{\gamma}(A, Z)$
   where $P_{\gamma} = \tilde{\xi}_{\text{surviv}} \cdot \tilde{\xi}_{\text{ratio}} \cdot \tilde{\xi}_{\gamma} \cdot \tilde{\xi}_{\text{detector}}$

c. $Y_{\gamma}(A, Z) = Y_{\text{frag}}(A, Z) \cdot \text{RefDens} + Y_{\gamma_{\text{isomer}}}(A, Z)$
$^{136}$Xe (140.0 MeV/u) + Be (500 μm); Settings on $^{123}$Ag

Identification 2D-plot in coincidence with $\gamma$-rays: Monte Carlo

Reference G/F=1

Isomeric Gamma Spectrum (after FP_slits)
Isomer γ–spectrum (for one isotope) from the identification 2D-plot

It was done for both methods:
- Monte Carlo
- “ellipse” mode
from 12/16/2005

γ-analysis: $^{123}\text{Ag}$
from the experiment #3034

T1/2 = 214 ns
$^{123}\text{Ag}$

T1/2 = 310 ns
$^{125}\text{Ag}$
$^{123}$Ag

$\gamma$-spectrum:
from the experiment #3034
&
LISE simulation

Temporary.
Waiting for final version of B.Tomlin's thesis

<table>
<thead>
<tr>
<th>Egamma</th>
<th>Igamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>350.</td>
<td>30.</td>
</tr>
<tr>
<td>384.</td>
<td>20.</td>
</tr>
<tr>
<td>391.</td>
<td>20.</td>
</tr>
<tr>
<td>630.</td>
<td>20.</td>
</tr>
<tr>
<td>686.</td>
<td>20.</td>
</tr>
<tr>
<td>714.</td>
<td>100.</td>
</tr>
<tr>
<td>733.</td>
<td>40.</td>
</tr>
<tr>
<td>770.</td>
<td>10.</td>
</tr>
<tr>
<td>1049.</td>
<td>10.</td>
</tr>
<tr>
<td>1077.</td>
<td>10.</td>
</tr>
<tr>
<td>1134.</td>
<td>10.</td>
</tr>
</tbody>
</table>

Isomeric Gamma Spectrum (after FP_slits): $^{123}$Ag

$^{136}$Xe (140.0 MeV$\alpha$) + Be (500 $\mu$m); Settings on $^{123}$Ag; Config: CDSVDDMSVM
Flight Length = 35.5 m; Rates[1/s]; ITgamma=6.2e-02; Reference=1.1e-02; Fragments=1.1e+03
Ref.GF = 1; Gamma efficiency at 1330 keV = 0.939%; Acquisition Delay=0.0ms; Gate=10.0ms

T1/2 = 214 ns
$^{123}$Ag

T1/2 = 310 ns
$^{125}$Ag
Acknowledgments

Prof. Paul Mantica
Dr. Jean-Michel Daugas
Dr. Constantin Vaman
NSCL separator meeting participants
Projectile fragmentation: new option for momentum distribution

Assume symmetric velocity distribution aroundProjectile / 2
It is important for light fragments.

for all models