NUCLEAR INFORMATION ON UNSTABLE NUCLEI FOR ASTRO-PHYSICS STUDIES

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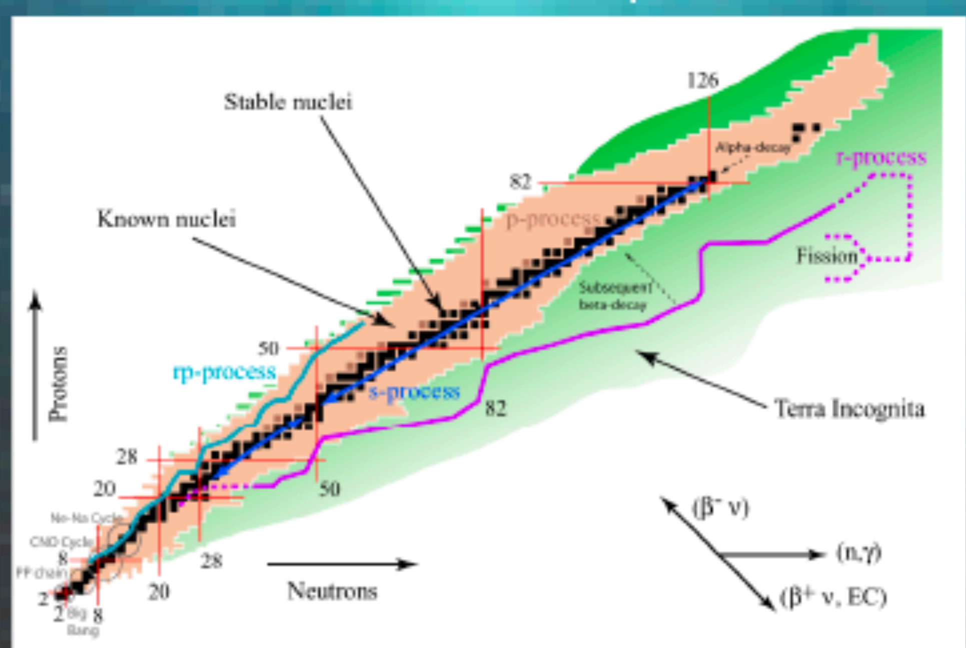
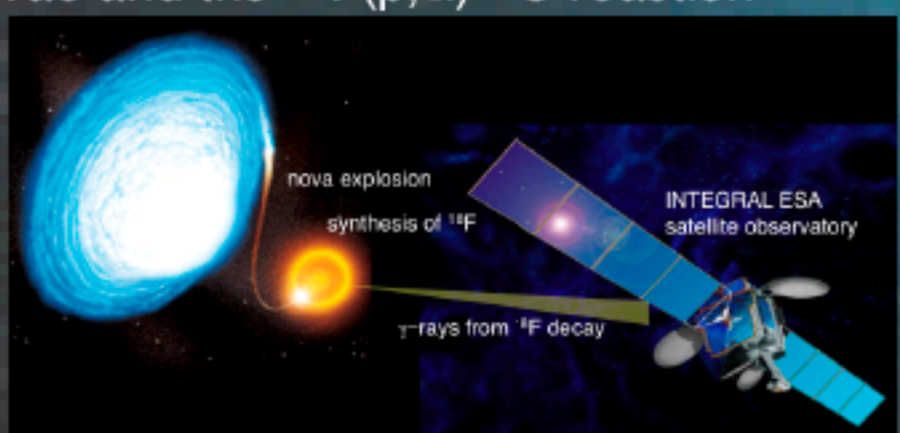
unstable nuclei and stellar explosions



- reactions on p-rich unstable nuclei power novae and X-ray bursts, and on n-rich unstable nuclei create heavy elements in supernovae
- complex simulations of these explosions require structure & reaction information on ~ thousands of **unstable nuclei** as input
- some reactions measured at radioactive beam facilities, many more as next generation facilities come online

1

Novae and the ^{18}F(p,α)^{15}O reaction



- this reaction destroys ^{18}F that is synthesized in novae
- an increase in the reaction rate results in less ^{18}F to decay (2 hour half-life) in the material ejected by the explosion
- this changes the ^{17}O/^{18}O abundance ratio in the ejecta, and results in therefore a smaller observable decay signature for orbital gamma-ray telescopes such as INTEGRAL
- series of measurements over 10 years at ORNL's Holifield Radio-active Ion Beam Facility, at Louvain-la-Neuve, and at ANL ATLAS have greatly improved our knowledge of this reaction
- important to combine all of this information in an evaluation

2

Evaluation of the ^{18}F(p,α)^{15}O reaction

- Goal: assess all info on ^{19}Ne levels above the ^{18}F + p threshold
- evaluation of 28 levels – from 6.4 to 8.1 MeV
- made estimates of unmeasured ^{19}Ne level parameters
- multi-year project: numerous RIB experiments from 2000 - 2006 forced numerous updates!
- Published C.D. Nesaraja et al.: Phys. Rev. C75 (2007) 055809
- another evaluation update needed to incorporate new measurements at ISAC, Louvain-la-Neuve, and HRIBF

3

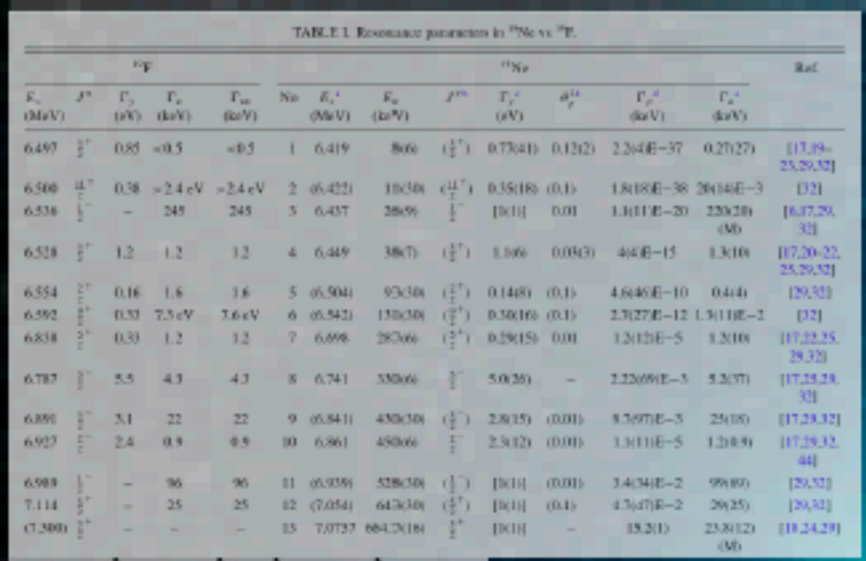
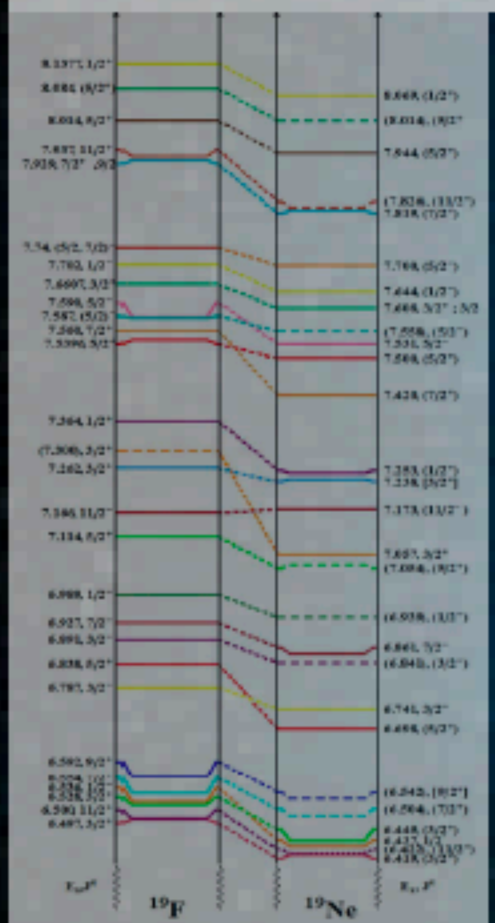


TABLE I. Resonance parameters in ^{18}Ne vs ^{19}F.



Novae and the ^{21}Na(p,γ)^{22}Mg reaction

- the reaction produces ^{22}Na (after decay of ^{22}Mg) in novae
- an increase in the reaction rate results in more ^{22}Na to decay (2.6 year half life) in the material ejected by the explosion
- this gives a larger observable decay signature for orbital gamma-ray telescopes such as COMPTEL and INTEGRAL
- COMPTEL search set an upper limit *below* that predicted by nova models using current reaction rates
- is the reaction rate wrong ? or another effect [e$^-$ screening ?]
- reaction was measured with a radioactive ^{21}Na beam at TRIUMF ISAC directly (p,γ) in 2003 and indirectly (p,p) in 2002
- important to combine these results, and level information from stable beam studies, in an evaluation

4

Evaluation of the ^{21}Na(p,γ)^{22}Mg reaction

- Goal: assess all info on ^{22}Mg levels above the ^{21}Na + p threshold
- Goal: determine new rate from improved level information, and subsequent impact on ^{22}Na production in novae
- new evaluation of 7 levels – from 5.7 to 6.6 MeV – in progress (Ouellet & Chen 2009) closely follows Chen et al. Nucl. Phys. A752 (2005) 510c
- rate is dominated by two resonances – at 0.1 GK by level at 206 keV [for novae], at 1.1 GK by level at 825 keV [for X-ray bursts]
- the 1 meV strength of 206 keV level changes rate down by 33 % and up by factor of 7 from two previous estimates (see Bishop et al., Phys. Rev. Lett. 90 (203) 162501).

5

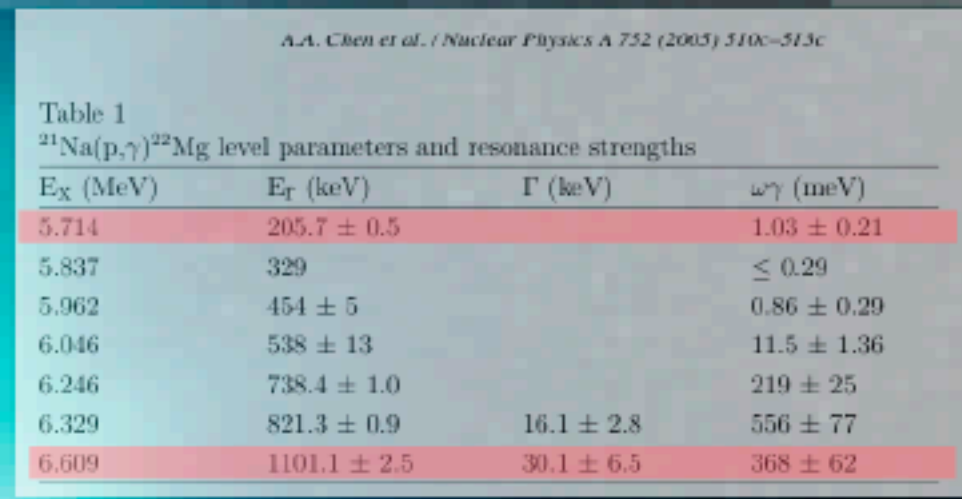
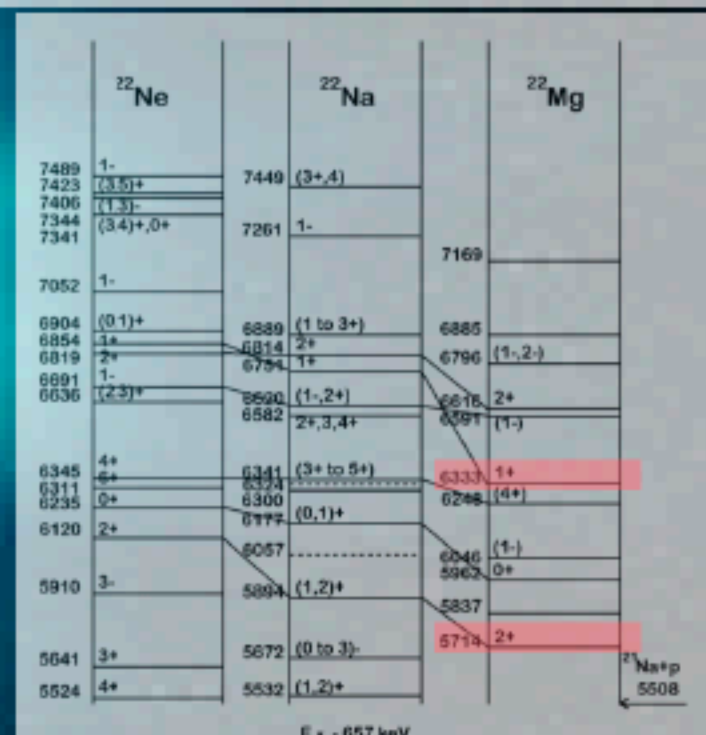

A.A. Chen et al. / Nuclear Physics A 752 (2005) 510c–513c

Table 1
^{21}Na(p,γ)^{22}Mg level parameters and resonance strengths

E_X (MeV)	E_R (keV)	Γ (keV)	$\omega\gamma$ (meV)
5.714	205.7 ± 0.5		1.03 ± 0.21
5.837	329		≤ 0.29
5.962	454 ± 5		0.86 ± 0.29
6.046	538 ± 13		11.5 ± 1.36
6.246	738.4 ± 1.0		219 ± 25
6.329	821.3 ± 0.9	16.1 ± 2.8	556 ± 77
6.609	1101.1 ± 2.5	30.1 ± 6.5	368 ± 62



Ruiz et al. Phys. Rev. C71 (2005) 025802

nuclear data – strategies for the future

- new measurements, new facilities, new complex models – greater need for data evaluations than ever before !
- problem: aging workforce in nuclear data, decreased funding overall
- result: significant decline in manpower to compile, evaluate, & disseminate this nuclear information on unstable nuclei
- **new strategies** needed to ensure that this crucial work continues
  - perform streamlined evaluations to reduce workload
  - develop software tools to aid in data processing / dissemination
  - develop workflow management tools to aid in data evaluations
  - enhance communications to avoid redundancies
  - form international collaborations to pool resources
  - recruit scientists for part-time evaluations, part-time research
- some of these (processing, dissemination, workflow software) are now available in the **Computational Infrastructure for Nuclear Astrophysics** at **nucastrodata.org**

6