Nuclear Chemistry in the Cosmos:
The Birth of Elements in Stellar Death

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Nuclear physics experiments

Nuclear physics theory

Astrophysics theory

Astronomical observations

Nuclear Astrophysics
Why is this barn red?
Lots of iron!

A lot less gold!

Wm. F. Sheehan Ref. Chem. 1976
Where did this come from?

“I am the badge of Phanes”
Where did this come from?

Electrum

- Silver: 30%
- Gold: 50%
- Ag or Au: 20%
Where is gold made?
Where is gold made?
LIGO/VIRGO NS Merger: https://www.youtube.com/watch?v=_SQbaILipjY
LIGO BH Merger: https://www.youtube.com/watch?v=QyDcTbR-kEA
Everything around you was processed in a star

Jennifer Johnson, OSU
Everything around you was processed in a star.

Regular stars made ~1/2 of the stuff around you. Most stars eventually become ‘planetary nebulae’

Stellar explosions made most of the rest. Some stars explode, like ‘supernovae’

The gas released formed everything around you.
Much like a chemical reaction, heat release from nuclear reactions can drive explosions.

*Gummi bear in potassium chlorate:*

*X-ray Burst on a neutron star:*
Where does nuclear physics come in?

Model output:

Model:

Brightness

↑

Time (s)

50 100 150 200

Reaction rate adjustor:

XRB Modeler 2000

Rate
WORTH

Just Because You’re Necessary Doesn’t Mean You’re Important.
Does this rate variation matter?
the rate variation is right

Does this rate variation matter?

1: $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$

2: $^{15}\text{O}(\alpha,\gamma)^{19}\text{Ne}$

3: $^{59}\text{Cu}(p,\gamma)^{60}\text{Zn}$

4: $^{72}\text{Kr}(p,\gamma)^{73}\text{Rb}$
Now that we know what’s important … what do we do about it?
Good news everyone! I made ____!
Isotope Production: Roulette in the Laboratory

Good news everyone! I made ____!

How do we actually produce the beam?
Beam Acceleration
Radiation Detection

Diagram showing an ionization chamber with labeled parts:
- Atom
- Anode
- Electron
- Ion
- Cathode (Cylinder Wall)
- Mica Window

Survey Meter Output

NDT Resource Center
The world is a radioactive place!

“large diffusion cloud chamber with radon gas double-decaying!”
(Source: biomerd23)
http://www.youtube.com/watch?v=Efgy1bY2aQ0
Nuclear physics can be useful…

“Oh, and I suppose it was me who said ‘what harm could it be to give the chickens a book on nuclear physics?’”
Where does strontium come from?

Sr is a Ca substitute.
Where does strontium come from?

Sakurai’s Object

Model Results

Knobs were tuned here!

P. Woodward, U Minn.

F. Herwig, U. Victoria

HE0338-3945

Sakurai’s Object Modeler:

(where the knobs were tuned)
We are star stuff
modeler results follow
12C(α,γ)16O \[\text{back to the modeler}\]
\(^{15}\text{O}(\alpha, \gamma)^{19}\text{Ne}\) causes a significant change!
$^{59}\text{Cu}(p,\gamma)^{60}\text{Zn}$ causes a significant change!

Flux [$10^{-9}$ erg cm$^{-2}$ sec$^{-1}$]
72Kr(p,γ)73Rb

...has a marginal impact!

back to the modeler