

GAMMA RAY LINES IN MODERN ASTROPHYSICS FIONA H. PANTHER | @FIPANTHER

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EXAMPLES FROM THE 2015 AUSTRALIAN DECADAL SURVEY:

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X-ray, **gamma-ray** and non-thermal radio observations

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INTEGRAL HAS MADE SIGNIFICANT CONTRIBUTIONS TOWARD PROVIDING SOME ANSWERS TO EACH OF THESE QUESTIONS, IN PARTICULAR THROUGH THE STUDY OF GAMMA RAY LINES



26Al rotates with the galaxy, but faster than molecular gas/stars...

Bouchet+2015





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- Iron in superbubbles? (Krause+)





Wang+2007

















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-50

0

Galactic longitude (deg)

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60Fe

26AI

-150

-100

Galactic latitude (deg) Galactic latitude (deg)

Fujimoto+2018

15

10

5

0

-5

-10

-15

15 10

5

0

-5

-10

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100

50

150

 10^{-6}

 10^{-7}



Cas A, Grefenstette+2017





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- SN1991bg ongoing nucleosynthesis in >6Gyr old stellar populations. The oldest SN.





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- Scatter in intrinsic SN la properties leads to systematics in cosmology beyond statistics
- It's all very well to 'remove' these systematics using e.g. host galaxy properties, but there is more to this.
 Optical/IR yields very limited information.



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The dream: a large sample of SNe Ia detected promptly in gamma-ray from which statistically significant conclusions can be drawn and from which explosion models can be tested



Positron annihilation



Positron annihilation



Observable

Information about ISM where annihilation occurs
Positron annihilation



Observable

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Information about physics of underlying source (nucleosynthesis? compact objects? Exotic phenomena?)

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Positron annihilation

510 Energy [keV]

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Positron astrophysics provides an opportunity to **understand cosmic ray propagation**, if we can better understand the source of positrons

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- These problems must be tackled simultaneously



POSITRON ANNIHILATION

Siegert+2016 Wiedenspointner+2008

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 - Positrons propagate over kpc distances, and all bets are off.





Galactic Longitude

330

75,000 h

1. "Outside in" transport (Prantzos+2006, Higdon+2009)

30





Galactic Longitude

330

300

Sn

75,000 h

30

60

90

270 2. Special source: SMBH: (Jean+2016, Totani 2006), Dark Matter (Finkbeiner & Weiner+2007, Boehm+2009)?



Galactic Longitude

75,000 h

Arm

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3. Old stars: Microquasars? (Guessoum+2006, Siegert+2016b), supernovae (Crocker+2017)

90

30

Juter

Inseus

300

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Galactic Longitude

75,000 ly

Arm

5,00Ó I

30

Outer

Inseus

60

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4. "Inside out" Transport: Diffusion (Jean+2009, Alexis+2012). Advection (Panther+2018a)

270°

330

SD

Arn



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 - Where are the positrons coming from?



OTHER ISOTOPES: CONSTRAINING SN EXPLOSION MODELS AND MORE


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We are looking beyond the Milky Way: Globular Clusters, dSph galaxies - talk to T. Siegert and I

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Australian National University



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Standardizing SN LCs based on gamma-ray observations, understanding SNe Ia explosion mechanism













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Catching nucleosynthesis in the act, kinematics of radioactive material, distribution of COs, indirect implications of nucleosynthesis byproducts (positrons)













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- Standardizing SN LCs based on gamma-ray observations, understanding SNe Ia explosion mechanism

cosmic time?
Kinematics of material synthesised in stellar death-throes

- How are elements produced by stars and recycled through galaxies?
- What is the nature of matter and gravity at extreme densities?

Catching nucleosynthesis in the act, kinematics of radioactive material, distribution of COs, indirect implications of nucleosynthesis byproducts (positrons)

- Multimessenger observational synergies









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at extreme densities? <









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