Stellar Beacons:
Classical Novae, Type Ia Supernovae, X-Ray Bursts & Stellar Mergers

Jordi José

Dept. Física i Enginyeria Nuclear, Univ. Politècnica de Catalunya (UPC)
& Institut d’Estudis Espacials de Catalunya (IEEC), Barcelona

Type Ia (or thermonuclear) **Supernovae** [SN Ia]
Classical Nova Outbursts [CN]
} WD

X-Ray Bursts [XRBs]: NS

I. Compact Star Mergers

NS+NS mergers

* On the astrophysical robustness of the neutron star merger r-process
Korobkin, O., Rosswog, S., Arcones, A., & Winteler, C. (2012), **MNRAS** 426, 1940

* r-process nucleosynthesis in dynamically ejected matter of neutron star mergers
Goriely, S., Bauswein, A., & Janka, H.-T. (2011), **ApJL** 738, L32

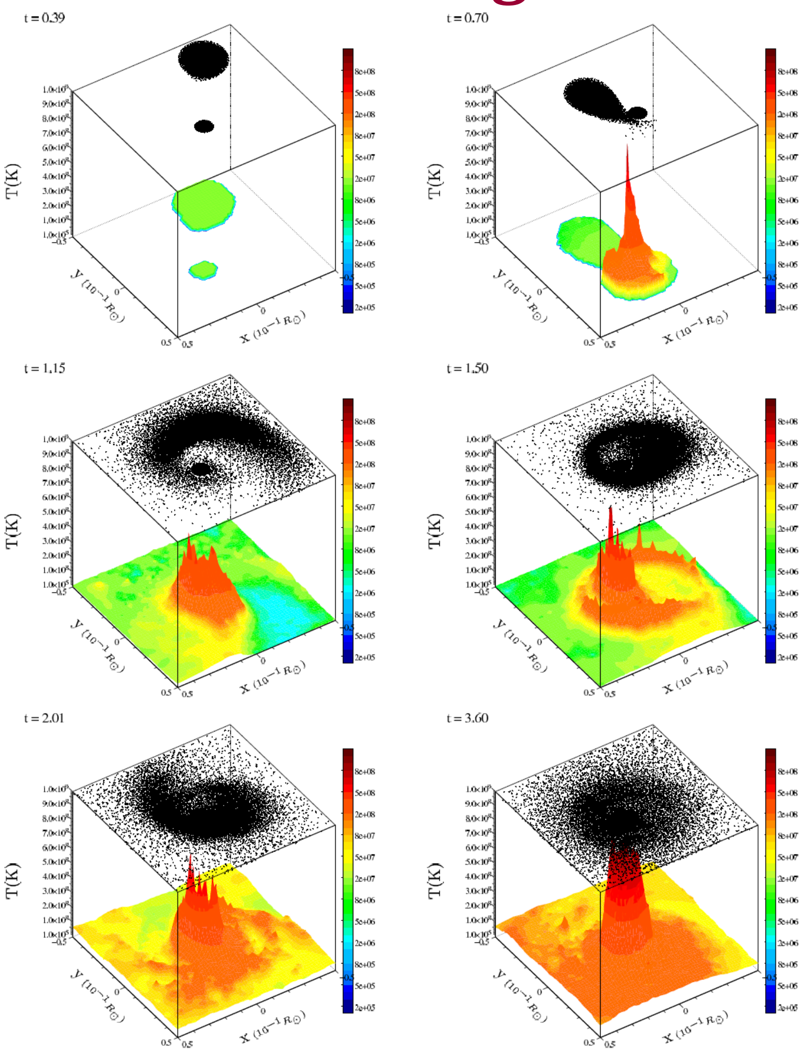
* Opacities and spectra of the r-process ejecta from neutron star mergers
Kasen, D., Badnell, N.R., & Barnes, J. (2013), **ApJ**, submitted

NS+WD mergers

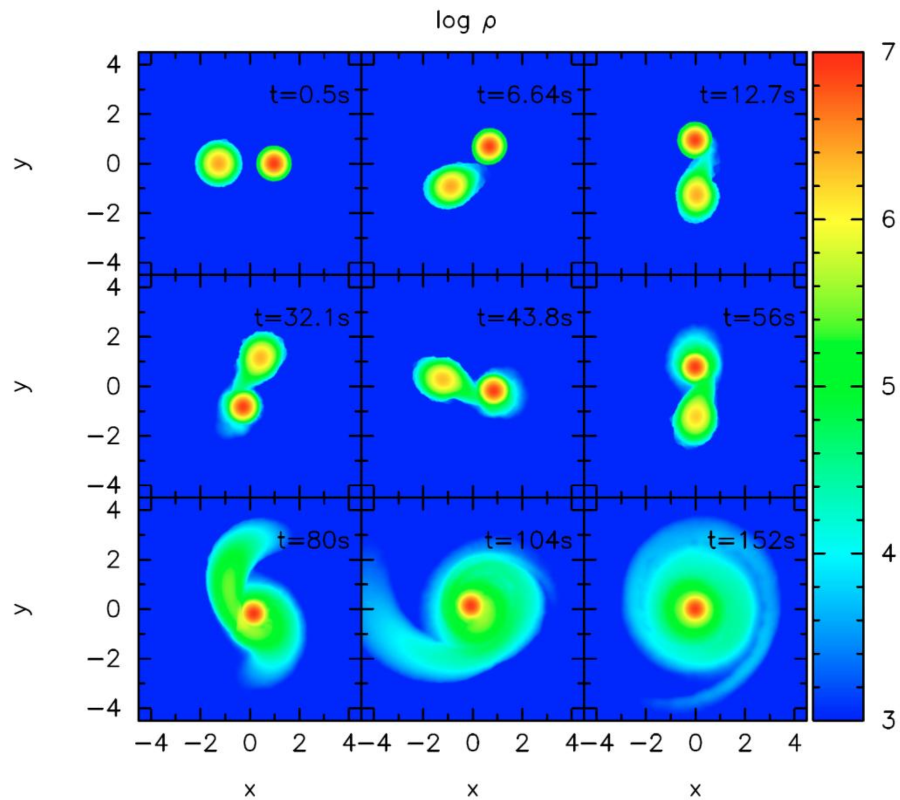
* Nuclear-dominated accretion and subluminous supernovae from the merger of a white dwarf with a neutron star or black hole
Metzger, B. D. (2012), **MNRAS** 419, 827

* Merger of binary white dwarf-neutron stars: Simulations in full general relativity
Paschalidis, V., Liu, Y.T., Etienne, Z., Shapiro, S.L. (2011), **Phys. Rev. D** 84, 104032

WD+WD mergers



Guerrero, García-Berro & Isern (2004)



Merging of two white dwarf stars
Lorén-Aguilar, Isern & García-Berro (2009)

Mon. Not. R. Astron.

García-Berro's talk, this Conference

€

Detonations in white dwarf dynamical interactions

G. Aznar-Siguán[1,2], E. García–Berro[1,2], P. Lorén–Aguilar[3], J. José[4,2] and J. Isern[5,2]
[1] *Departament de Física Aplicada, Universitat Politècnica de Catalunya, c/Esteve Terrades 5, 08860 Castelldefels, Spain*
[2] *Institute for Space Studies of Catalonia, c/Gran Capità 2–4, Edif. Nexus 104, 08034 Barcelona, Spain*
[3] *School of Physics, University of Exeter, Stocker Road, Exeter, UK EX4 4QL, United Kingdom*
[4] *Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, c/Comte d'Urgell 187, 08036 Barcelona, Spain*
[5] *Institut de Ciències de l'Espai, CSIC, Campus UAB, Facultat de Ciències, Torre C-5, 08193 Bellaterra, Spain*

High resolution simulations of the head-on collision of white dwarfs

€€

D. García-Senz[1,2⋆], R.M. Cabezón[3], A. Arcones[4,5], A. Relaño [1] and F.K. Thielemann[3]
[1] *Departament de Física i Enginyeria Nuclear. Universitat Politècnica de Catalunya. c/Compte d'Urgell 187. 08036 Barcelona, Spain*
[2] *Institut d'Estudis Espacials de Catalunya. c/Gran Capità 2-4, 08034 Barcelona, Spain*
[3] *Departement Physik. Universität Basel. Klingelbergstrasse, 82. 4056 Basel, Switzerland*
[4] *Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany*
[5] *GSI Helmholtzzentrum für Schwerionenforschung, Planckstrβe, 1. 64291 Darmstadt, Germany*

Peculiar abundances in some H-deficient stars with high C abundances (e.g., HdC, RCB, and EHe stars).

* Can R Coronae Borealis stars form from the merger of two helium white dwarfs?
Zhang, X., & Jeffery, C.S. (2012), **MNRAS** 426, L81

* Do R Coronae Borealis stars Form from double white dwarf mergers?
Staff, J.E., Menon, A., Herwig, F., Even, W., Fryer, C.L., Motl, P.M., Geballe, T., Pignatari, M., Clayton, G., Tohline, J.E. (2012) , **ApJ** 757, 76

* The circumstellar environment of R Coronae Borealis: white dwarf merger or final-helium-shell flash?
Clayton, G.C., Sugerman, B.E.K., Stanford, S.A., Whitney, B.A., Honor, J., Babler, B., Barlow, M.J., Gordon, K.D., Andrews, J.E., Geballe, T.R., Bond, H.E., De Marco, O., Lawson, W.A., Sibthorpe, B., Olofsson, G., Polehampton, E., Gomez, H.L., Matsuura, M., Hargrave, P.C., Ivison, R.J., Wesson, R., Leeks, S.J., Swinyard, B.M., & Lim, T.L. **ApJ** (2011), 743, 44

* Double white dwarf mergers and elemental surface abundances in extreme helium and R Coronae Borealis stars
Jeffery, C.S., Karakas, A.I., & Saio, H. (2011), MNRAS 414, 3599

The Astrophysical Journal Letters, 737:L34 (4pp), 2011 August 20
doi:10.1088/2041-8205/737/2/L34

€

NUCLEOSYNTHESIS DURING THE MERGER OF WHITE DWARFS AND THE ORIGIN OF R CORONAE BOREALIS STARS

R. Longland[1,2], P. Lorén-Aguilar[2,3], J. José[1,2], E. García-Berro[2,3], L. G. Althaus[4], and J. Isern[2,5]
[1] Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, c/Comte d'Urgell 187, E-08036 Barcelona, Spain; richard.longland@upc.edu
[2] Institut d'Estudis Espacials de Catalunya (IEEC), Ed. Nexus-201, C/Gran Capità 2-4, E-08034 Barcelona, Spain
[3] Departament de Física Aplicada, Universitat Politècnica de Catalunya, c/Esteve Terrades, 5, E-08860 Castelldefels, Spain
[4] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, (1900) La Plata, Argentina
[5] Institut de Ciències de l'Espai (CSIC), Campus UAB, E-08193 Bellaterra, Spain

Longland's talk, this Conference

A&A 542, A117 (2012)
DOI: 10.1051/0004-6361/201219289

Astronomy & Astrophysics

Lithium production in the merging of white dwarf stars

€

R. Longland[1,2], P. Lorén-Aguilar[3,2], J. José[1,2], E. García-Berro[3,2], and L. G. Althaus[4]

[1] Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, C/ Comte d'Urgell 187, 08036 Barcelona, Spain
e-mail: richard.longland@upc.edu
[2] Institut d'Estudis Espacials de Catalunya (IEEC), Ed. Nexus-201, C/ Gran Capità 2-4, 08034 Barcelona, Spain
[3] Departament de Física Aplicada, Universitat Politècnica de Catalunya, C/ Esteve Terrades, 5, 08860 Castelldefels, Spain
[4] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, (1900) La Plata, Argentina

II. Classical Novae


PLAÇA
NOVA

Novae have been observed in all wavelengths (but never detected so far in γ-rays)

The Classical Nova ID Card

Moderate rise times (<1 – 2 days):

8 – 18 magnitude increase in brigthness

$L_{Peak} \sim 10^4 - 10^5\ L_\odot$

Stellar binary systems: WD + MS (often, K-M dwarfs)

Recurrence time: ~ 10 yr (RNe) – 10^5 yr (CNe)

Frequency: 30   10 yr^{-1}

Observed frequency: ~ 5 yr^{-1}

$E \sim 10^{45}$ ergs

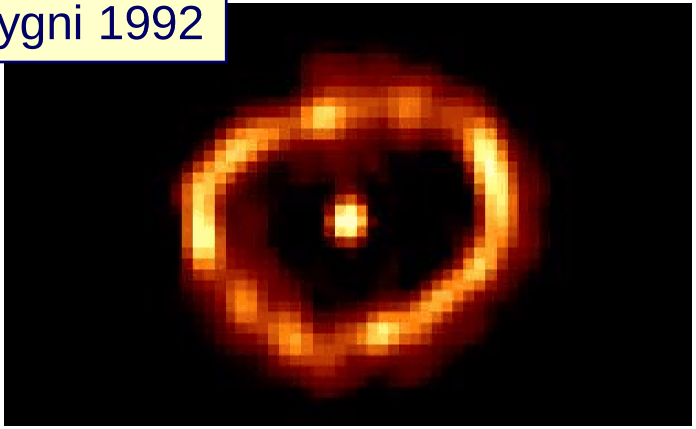
Mass ejected: $10^{-4} - 10^{-5}\ M_\odot$ ($\sim 10^3$ km s^{-1})

Early TNR models: Starrfield et al. 1972; Prialnik, Shara & Shaviv 1978

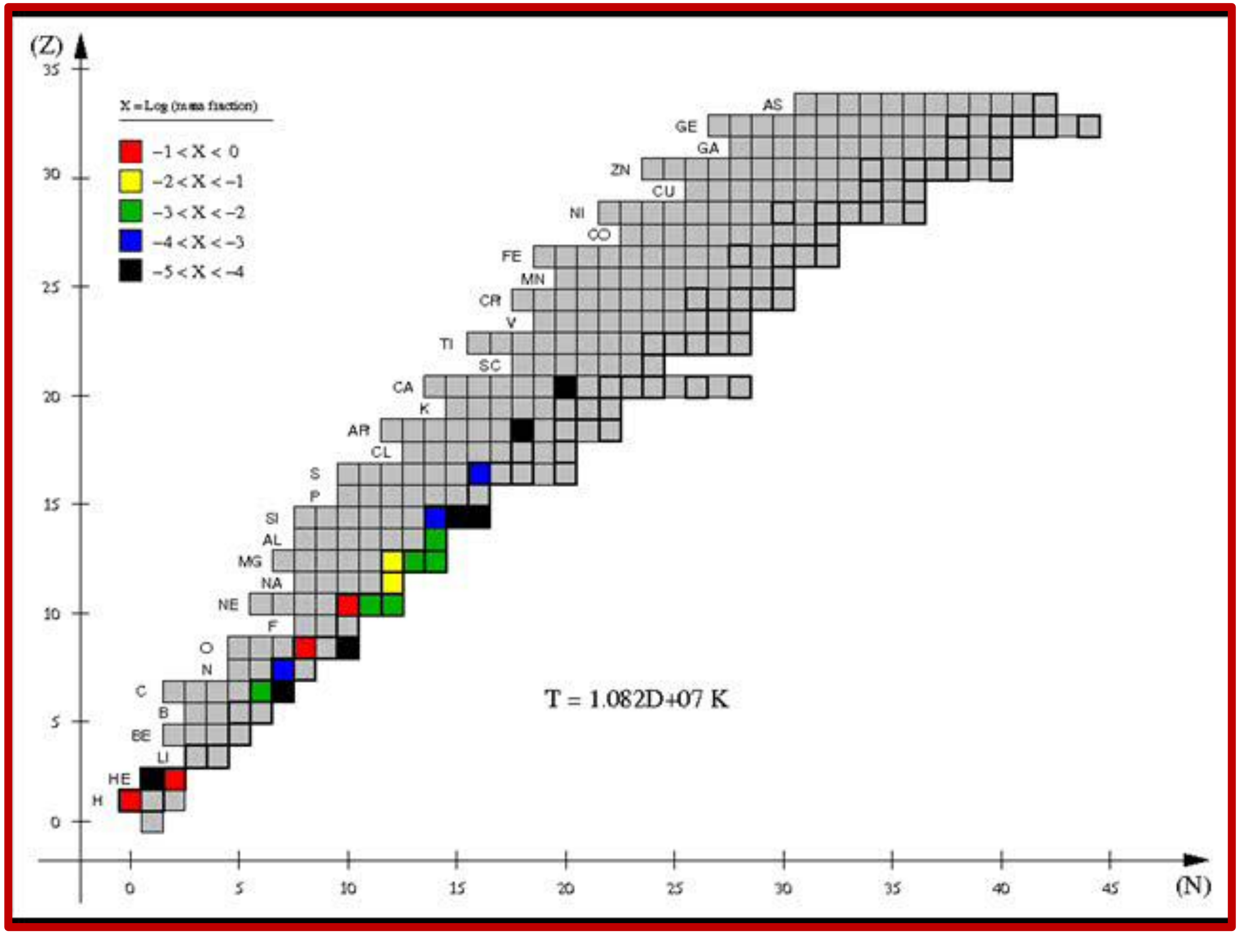
The Nova Nuclear Symphony

Classical Novae: ~**100** relevant isotopes **(A<40)** & a **(few) hundred** nuclear reactions **(T_{peak} ~ 100 – 400 MK)**

Nova Cygni 1992



Novae as **unique stellar explosions** for which the nuclear physics input is (will be) primarily based on <u>experimental information</u> (JJ, Hernanz & Iliadis, Nucl. Phys. A 2006)



1.35 $M_{\odot}$, 2 10^{-10} $M_{\odot}.yr^{-1}$, Z=Solar (+50% pre-enrichment)

€€

Classical Novae: JJ, Hernanz, Coc & Iliadis (2013), in prep.

Model 1.35 $M_\odot$ (50% ONe enrichment)

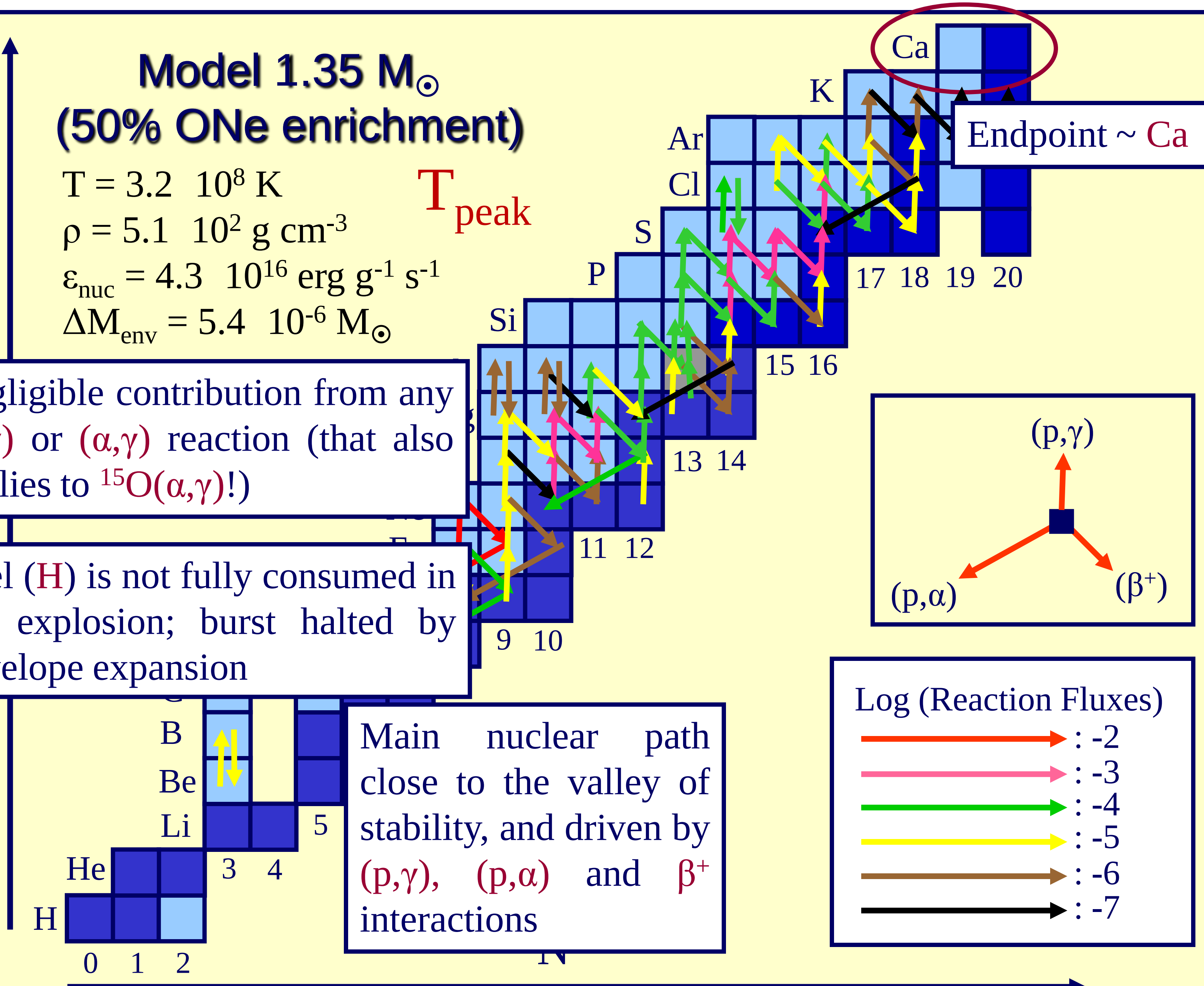
$T = 3.2 \;\; 10^{8}$ K

$\rho = 5.1 \;\; 10^{2}$ g cm^{-3}

$\varepsilon_{nuc} = 4.3 \;\; 10^{16}$ erg g^{-1} s^{-1}

$\Delta M_{env} = 5.4 \;\; 10^{-6} \; M_\odot$

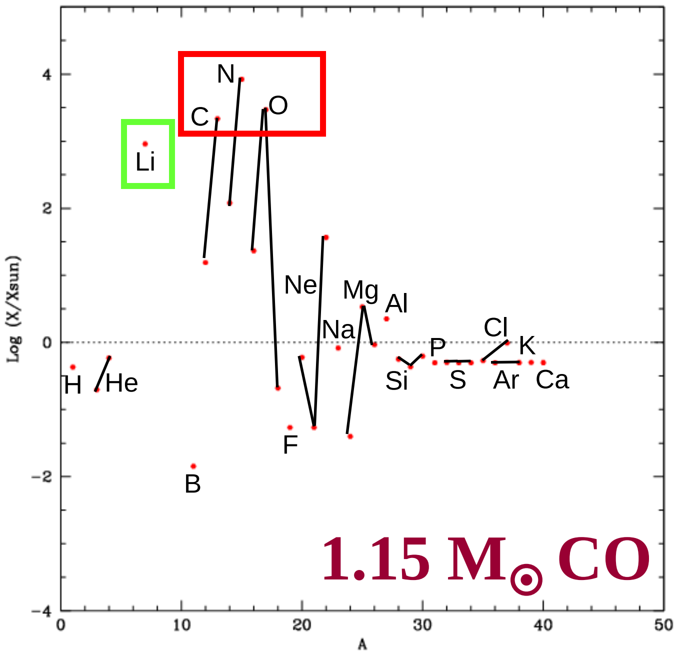
T_{peak}

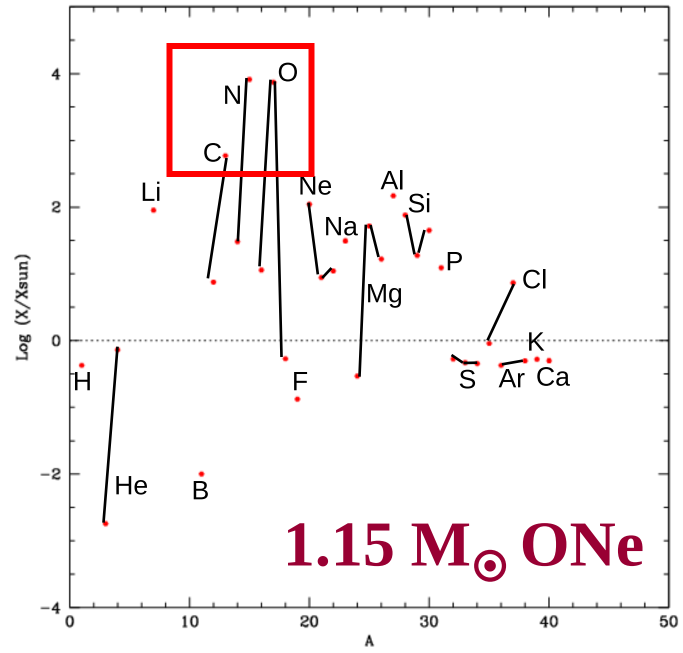


Negligible contribution from any (n,γ) or (α,γ) reaction (that also applies to ^{15}O(α,γ)!)

Fuel (H) is not fully consumed in the explosion; burst halted by envelope expansion

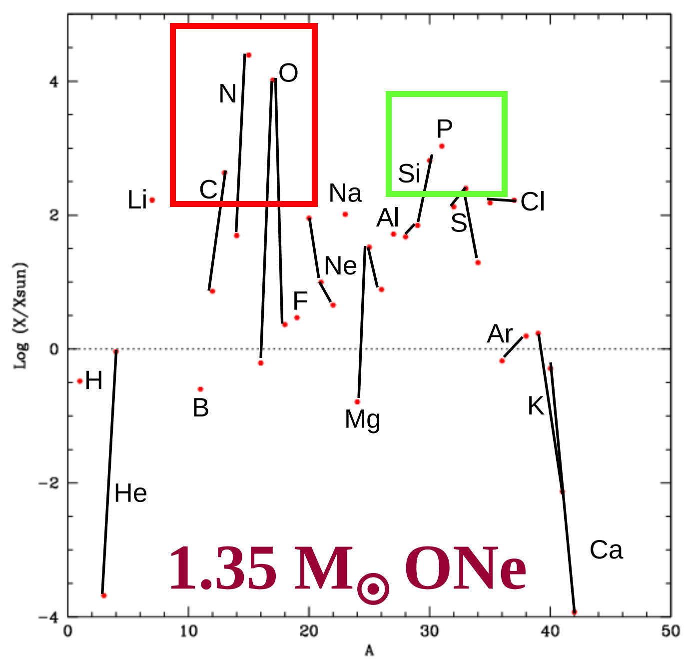
Main nuclear path close to the valley of stability, and driven by (p,γ), (p,α) and β^+ interactions





JJ, Hernanz, Coc & Iliadis (2013), in preparation

€€



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics A 841 (2010) 1–30

NUCLEAR PHYSICS A

www.elsevier.com/locate/nuclphysa

Charged-particle thermonuclear reaction rates: I. Monte Carlo method and statistical distributions

R. Longland [a,b], C. Iliadis [a,b,*], A.E. Champagne [a,b], J.R. Newton [a,b], C. Ugalde [a,b], A. Coc [c,d], R. Fitzgerald [e]

[a] Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA
[b] Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308, USA
[c] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), UMR 8609, CNRS/IN2P3, France
[d] Université Paris Sud 11, Bâtiment 104, 91405 Orsay Campus, France
[e] National Institute of Standards and Technology, 100 Bureau Drive, Stop 8462, Gaithersburg, MD 20899-8462, USA

Received 21 December 2009; receive…

Avail…

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics A 841 (2010) 31–250

NUCLEAR PHYSICS A

www.elsevier.com/locate/nuclphysa

Charged-particle thermonuclear reaction rates: II. Tables and graphs of reaction rates and probability density functions

C. Iliadis [a,b,*], R. Longland [a,b], A.E. Champagne [a,b], A. Coc [c], R. Fitzgerald [d]

[a] Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA
[b] Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308, USA
[c] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), UMR 8609, CNRS/IN2P3 and Université Paris Sud 11, Bâtiment 104, 91405 Orsay Campus, France
[d] National Institute of Standards and Technology, 100 Bureau Drive, Stop 8462, Gaithersburg, MD 20899-8462, USA

… April 2010; accepted 22 April 2010

… 2010

Simulations performed with the new reaction rate compilation of **Iliadis et al. (2010)**

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics A 841 (2010) 251–322

NUCLEAR PHYSICS A

www.elsevier.com/locate/nuclphysa

Charged-particle thermonuclear reaction rates: III. Nuclear physics input

C. Iliadis [a,b,*], R. Longland [a,b], A.E. Champagne [a,b], A. Coc [c]

[a] Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA
[b] Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308, USA
[c] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), UMR 8609, CNRS/IN2P3 and Université Paris Sud 11, Bâtiment 104, 91405 Orsay Campus, France

Received 21 December 2009; received in revised form 21 April 2010; accepted 22 April 2010

Available online 1 May 2010

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics A 841 (2010) 323–388

NUCLEAR PHYSICS A

www.elsevier.com/locate/nuclphysa

Charged-particle thermonuclear reaction rates: IV. Comparison to previous work

C. Iliadis [a,b,*], R. Longland [a,b], A.E. Champagne [a,b], A. Coc [c]

[a] Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA
[b] Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308, USA
[c] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), UMR 8609, CNRS/IN2P3 and Université Paris Sud 11, Bâtiment 104, 91405 Orsay Campus, France

Received 21 December 2009; received in revised form 21 April 2010; accepted 22 April 2010

Available online 1 May 2010

Nuclear Uncertainties

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 142:105–137, 2002 September

THE EFFECTS OF THERMONUCLEAR REACTION-RATE VARIATIONS ON NOVA NUCLEOSYNTHESIS: A SENSITIVITY STUDY

CHRISTIAN ILIADIS AND ART CHAMPAGNE
Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255; and Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308; iliadis@unc.edu, aec@tunl.duke.edu

JORDI JOSÉ
Departament de Física i Enginyeria Nuclear (UPC), Avinguda Víctor Balaguer, s/n, E-08800 Vilanova i la Geltrú, Barcelona, Spain; and Institut d'Estudis Espacials de Catalunya, Edifici Nexus-201, Calle Gran Capitá 2-4, E-08034 Barcelona, Spain; jjose@ieec.fcr.es

SUMNER STARRFIELD
Department of Physics and Astronomy, Arizona State University, Tempe, AZ 85287-1504; sumner.starrfield@asu.edu

AND

PAUL TUPPER
Scientific Computing–Computational Mathematics Program, Stanford University, Stanford, CA 94305; tupper@sccm.stanford.edu
Received 2002 January 19; accepted 2002 April 25

$\approx$7350 nuclear reaction network calculations

Main nuclear uncertainties: [**^{18}F(p,α)^{15}O, ^{25}Al(p,γ)^{26}Si, ^{30}P(p,γ)^{31}S**]

MANY updates on reaction rates for nova nucleosynthesis since then (and since May 2010...)

€€

PHYSICAL REVIEW C **83**, 034611 (2011)

Absolute determination of the ^{22}Na$(p,\gamma)^{23}$Mg reaction rate in novae

A. L. Sallaska,[1,*] C. Wrede,[1] A. García,[1] D. W. Storm,[1] T. A. D. Brown,[1,†] C. Ruiz,[2] K. A. Snover,[1] D. F. Ottewell,[2] L. Buchmann,[2] C. Vockenhuber,[2,‡] D. A. Hutcheon,[2] J. A. Caggiano,[2,§] and J. José[3]
[1]*Department of Physics, University of Washington, Seattle, Washington 98195-1560, USA*
[2]*TRIUMF, Vancouver, BC V6T 2A3, Canada*
[3]*Departament Física i Enginyeria Nuclear (UPC) and Institut d'Estudis Espacials de Catalunya (IEEC), E-08034 Barcelona, Spain*
(Received 20 September 2010; revised manuscript received 18 December 2010; published 23 March 2011)

Underground measurement of ^{17}O$(p,\gamma)^{18}$F for explosive H burning

A. Di Leva,[1,2,*] D.A. Scott,[3] A. Caciolli,[4,5] A. Formicola,[6,†] F. Strieder,[7] M. Aliotta,[3] M. Anders,[8] D. Bemmerer,[8] C. Broggini,[4] P. Corvisiero,[9,10] Z. Elekes,[8] Zs. Fülöp,[11] G. Gervino,[12] A. Guglielmetti,[13,14] C. Gustavino,[15] Gy. Gyürky,[11] G. Imbriani,[1,2] J. José,[16] M. Junker,[6] M. Laubenstein,[6] R. Menegazzo,[4] E. Napolitani,[17] P. Prati,[9,10] V. Rigato,[5] V. Roca,[1,2] E. Somorjai,[11] C. Salvo,[6,10] O. Straniero,[18,2] T. Szücs,[11] F. Terrasi,[19,2] and D. Trezzi
(LUNA Collaboration)

€€€€

PRL **110,** 032502 (2013) PHYSICAL REVIEW LETTERS week ending 18 JANUARY 2013

Is γ-Ray Emission from Novae Affected by Interference Effects in the $^{18}F(p, \alpha)^{15}O$ Reaction?

A. M. Laird,[1,*] A. Parikh,[2,3] A. St. J. Murphy,[4] K. Wimmer,[5,6] A. A. Chen,[7] C. M. Deibel,[8,9] T. Faestermann,[10,11] S. P. Fox,[1] B. R. Fulton,[1] R. Hertenberger,[11,12] D. Irvine,[7] J. José,[2,3] R. Longland,[2,3] D. J. Mountford,[4] B. Sambrook,[7] D. Seiler,[10,11] and H.-F. Wirth[11,12]

[1]*Department of Physics, University of York, York YO10 5DD, United Kingdom*
[2]*Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, c/ Comte d'Urgell 187, E-08036 Barcelona, Spain*
[3]*Institut d'Estudis Espacials de Catalunya, c/Gran Capita 2-4, Ed. Nexus-201, E-08034 Barcelona, Spain*
[4]*SUPA, School of Physics and Astronomy, The University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom*
[5]*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*
[6]*Department of Physics, Central Michigan University, Mount Pleasant, Michigan 48859, USA*
[7]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4M1, Canada*
[8]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[9]*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*
[10]*Physik Department E12, Technische Universität München, DE-85748 Garching, Germany*
[11]*Maier-Leibnitz-Laboratorium der Münchner Universitäten (MLL), DE-85748 Garching, Germany*
[12]*Fakultät für Physik, Ludwig-Maximilians-Universität München, DE-85748 Garching, Germany*
(Received 11 October 2012; published 15 January 2013)

€€

PHYSICAL REVIEW C **83**, 045806 (2011)

Improving the ^{30}P(p,γ)^{31}S rate in oxygen-neon novae: Constraints on J^{π} values for proton-threshold states in ^{31}S

A. Parikh,[1,2,3,4,*] K. Wimmer,[3,4,5] T. Faestermann,[3,4] R. Hertenberger,[4,6] J. José,[1,2] R. Longland,[1] H.-F. Wirth,[4,6] V. Bildstein,[3,4] S. Bishop,[3,4] A. A. Chen,[7,8] J. A. Clark,[9] C. M. Deibel,[9,10] C. Herlitzius,[3,4] R. Krücken,[3,4,†] D. Seiler,[3,4] K. Straub,[3,4] and C. Wrede[11]

[1]*Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, E-08036 Barcelona, Spain*
[2]*Institut d'Estudis Espacials de Catalunya, E-08034 Barcelona, Spain*
[3]*Physik Department E12, Technische Universität München, D-85748 Garching, Germany*
[4]*Maier-Leibnitz-Laboratorium der Münchner Universitäten (MLL), D-85748 Garching, Germany*
[5]*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*
[6]*Fakultät für Physik, Ludwig-Maximilians-Universität München, D-85748 Garching, Germany*
[7]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4M1, Canada*
[8]*Excellence Cluster Universe, Technische Universität München, D-85748 Garching, Germany*
[9]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[10]*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*
[11]*Department of Physics, University of Washington, Seattle, Washington 98195, USA*

(Received 7 February 2011; published 27 April 2011)

€€

Nuclear structure of ^{30}S and its implications for nucleosynthesis in classical novae

K. Setoodehnia,[1,*] A. A. Chen,[1] D. Kahl,[2] T. Komatsubara,[3] J. José,[4,5] R. Longland,[4,5] Y. Abe,[3] D. N. Binh,[2] J. Chen,[1] S. Cherubini,[6,2] J. A. Clark,[7] C. M. Deibel,[8,7,†] S. Fukuoka,[3] T. Hashimoto,[2] T. Hayakawa,[9] J. Hendriks,[10] Y. Ishibashi,[3] Y. Ito,[3] S. Kubono,[2] W. N. Lennard,[10] T. Moriguchi,[3] D. Nagae,[3] R. Nishikiori,[3] T. Niwa,[3] A. Ozawa,[3] P. D. Parker,[11] D. Seiler,[12] T. Shizuma,[9] H. Suzuki,[3] C. Wrede,[13,‡] H. Yamaguchi,[2] and T. Yuasa[3]

[1] *Department of Physics & Astronomy, McMaster University, Hamilton, ON L8S 4M1, Canada*
[2] *Center for Nuclear Study (CNS), the University of Tokyo, Wako Branch at RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*
[3] *Institute of Physics, University of Tsukuba, Tennodai 1-1-1, Tsukuba, Ibaraki 305-8577, Japan*
[4] *Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, c/Comte d'Urgell 187, 08036 Barcelona, Spain*
[5] *Institut d'Estudis Espacials de Catalunya, c/Gran Capità 2-4, Ed. Nexus 201, 08034 Barcelona, Spain*
[6] *INFN-Laboratori Nazionali del Sud and Dipartimento di Fisica ed Astronomia Università di Catania, Via S. Sofia 6, 95123 Catania, Italy*
[7] *Physics Division, Argonne National Laboratory, Argonne, IL 60439, USA*
[8] *Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, MI 48824, USA*
[9] *Japan Atomic Energy Agency (JAEA), Tokai–mura, Ibaraki 3191195, Japan*
[10] *Department of Physics & Astronomy, Western University, London, ON N6A 5B7, Canada*
[11] *Wright Nuclear Structure Laboratory, Yale University, New Haven, CT 06520, USA*
[12] *Physik Department E12, Technische Universität München, D-85748 Garching, Germany*
[13] *Department of Physics, University of Washington, Seattle, WA 98195, USA*

(Dated: October 4, 2012)

€€

$^{29}P(p, \gamma)^{30}S$

€€

PHYSICAL REVIEW C **84**, 065808 (2011)

Production of ^{26}Al in stellar hydrogen-burning environments: Spectroscopic properties of states in ^{27}Si

A. Parikh,[1,2,3,4,*] K. Wimmer,[3,4,5,†] T. Faestermann,[3,4] R. Hertenberger,[4,6] H.-F. Wirth,[4,6] A. A. Chen,[7,8] J. A. Clark,[9] C. M. Deibel,[9,10,‡] C. Herlitzius,[3,4] R. Krücken,[3,4,§] D. Seiler,[3,4] K. Setoodehnia,[7] K. Straub,[3,4,‖] and C. Wrede[11,†]
[1]*Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, ES-08036 Barcelona, Spain*
[2]*Institut d'Estudis Espacials de Catalunya, ES-08034 Barcelona, Spain*
[3]*Physik Department E12, Technische Universität München, DE-85748 Garching, Germany*
[4]*Maier-Leibnitz-Laboratorium der Münchner Universitäten (MLL), DE-85748 Garching, Germany*
[5]*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*
[6]*Fakultät für Physik, Ludwig-Maximilians-Universität München, DE-85748 Garching, Germany*
[7]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, Canada L8S 4M1*
[8]*Excellence Cluster Universe, Technische Universität München, DE-85748 Garching, Germany*
[9]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[10]*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*
[11]*Department of Physics, University of Washington, Seattle, Washington 98195, USA*
(Received 22 August 2011; published 27 December 2011)

€€

PHYSICAL REVIEW C **82**, 035805 (2010)

Properties of ^{20}Na, ^{24}Al, ^{28}P, ^{32}Cl, and ^{36}K for studies of explosive hydrogen burning

C. Wrede,[1,2] J. A. Clark,[2,3] C. M. Deibel,[2,3,4] T. Faestermann,[5] R. Hertenberger,[6] A. Parikh,[5] H.-F. Wirth,[6] S. Bishop,[5] A. A. Chen,[7,8] K. Eppinger,[5] B. M. Freeman,[1] R. Krücken,[5] O. Lepyoshkina,[5] G. Rugel,[5] and K. Setoodehnia[7]
[1]*Department of Physics, University of Washington, Seattle, Washington 98195, USA*
[2]*Wright Nuclear Structure Laboratory, Yale University, New Haven, Connecticut 06520, USA*
[3]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[4]*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*
[5]*Physik Department E12, Technische Universität München, D-85748 Garching, Germany*
[6]*Fakultät für Physik, Ludwigs-Maximilians-Universität München, D-85784 Garching, Germany*
[7]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4M1, Canada*
[8]*DFG Cluster of Excellence Origin and Structure of the Universe, Technische Universität München, D-85748 Garching, Germany*
(Received 10 August 2010; published 29 September 2010)

Modeling the explosion: 1-D hydrodynamics

Bull. Astr. Soc. India (2012) **40**, 419–442

€

Theoretical studies of accretion of matter onto white dwarfs and the single degenerate scenario for supernovae of Type Ia

S. Starrfield[1*], C. Iliadis[2], F. X. Timmes[1], W. R. Hix[3], W. D. Arnett[4], C. Meakin[5] and W. M. Sparks[5]

[1]*School of Earth and Space Exploration, P.O. Box 871404, Arizona State University, Tempe, AZ 85287-1404, USA*
[2]*Dept. of Physics & Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA*
[3]*Dept. of Physics and Astronomy, University of Tennessee, Knoxville, TN 37996-1200, USA*
[4]*Dept. of Astronomy, University of Arizona, Tucson, AZ, 85721, USA*
[5]*Los Alamos National Laboratory, Los Alamos, NM, 87545, USA*

Baltic Astronomy, vol. 21, 76–87, 2012

€

HYDRODYNAMIC STUDIES OF THE EVOLUTION OF RECURRENT, SYMBIOTIC AND DWARF NOVAE: THE WHITE DWARF COMPONENTS ARE GROWING IN MASS

S. Starrfield[1], F. X. Timmes[1], C. Iliadis[2], W. R. Hix[3], W. D. Arnett[4], C. Meakin[5] and W. M. Sparks[5]

[1] *School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, U.S.A.; starrfield@asu.edu; fxt44@mac.com*
[2] *Dept. of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, U.S.A.; iliadis@unc.edu*
[3] *Dept. of Physics and Astronomy, University of Tennessee, Knoxville, TN 37996-1200, U.S.A.; raph@utk.edu*
[4] *Dept. of Astronomy, University of Arizona, Tucson, AZ 85721, U.S.A.; darnett@as.arizona.edu*
[5] *Los Alamos National Laboratory, Los Alamos, NM 87545, U.S.A.; casey.meakin@gmail.com; warrensparks@comcast.net*

Bull. Astr. Soc. India (2012) **40**, 443–456

€

Classical nova explosions – hydrodynamics and nucleosynthesis

J. José[1,2*]

[1]*Dept. Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, E-08036 Barcelona*
[2]*Institut d'Estudis Espacials de Catalunya, E-08034 Barcelona, Spain*

The Astrophysical Journal, 762:8 (10pp), 2013 January 1 doi:10.1088/0004-637X/762/1/8

MESA MODELS OF CLASSICAL NOVA OUTBURSTS: THE MULTICYCLE EVOLUTION AND EFFECTS OF CONVECTIVE BOUNDARY MIXING

Pavel A. Denissenkov[1,2,3], Falk Herwig[1,3,4], Lars Bildsten[5], and Bill Paxton[5]
[1] Department of Physics & Astronomy, University of Victoria, P.O. Box 3055, Victoria, BC V8W 3P6, Canada; pavelden@uvic.ca, fherwig@uvic.ca
[2] TRIUMF, 4004 Wesbrook Mall, Vancouver, BC V6T 2A3, Canada
[3] Joint Institute for Nuclear Astrophysics, Department of Physics, University of Notre Dame, Notre Dame, IN 46556, USA
[4] Turbulence in Stellar Astrophysics Program, New Mexico Consortium, Los Alamos, NM 87544, USA
[5] Kavli Institute for Theoretical Physics and Department of Physics, Kohn Hall, University of California, Santa Barbara, CA 93106, USA; bildsten@kitp.ucsb.edu, paxton@kitp.ucsb.edu
Received 2012 June 1; accepted 2012 October 18; published 2012 December 7

The Astrophysical Journal, 725:831–841, 2010 December 10 doi:10.1088/0004-637X/725/1/831

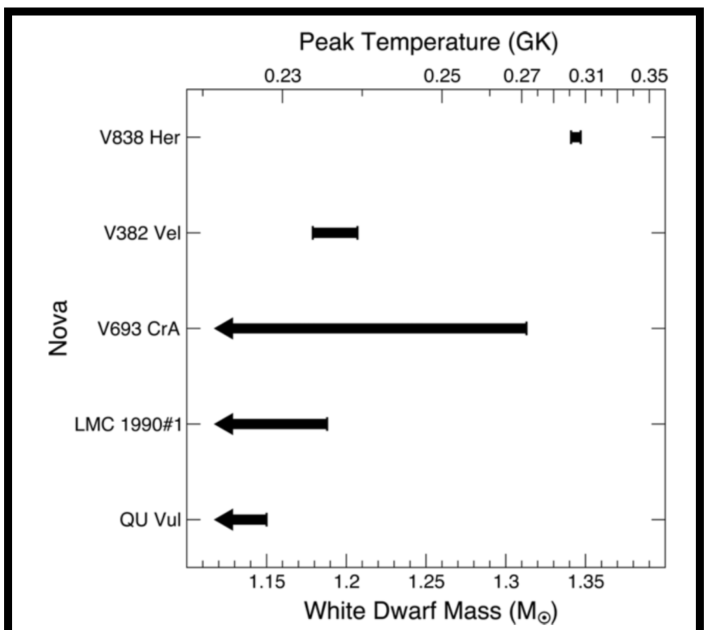
AN EXTENDED GRID OF NOVA MODELS. III. VERY LUMINOUS, RED NOVAE

Michael M. Shara[1], Ofer Yaron[2], Dina Prialnik[2], Attay Kovetz[2,3], and David Zurek[1]
[1] Department of Astrophysics, American Museum of Natural History, Central Park West and 79th Street, New York, NY 10024-5192, USA
[2] Department of Geophysics and Planetary Sciences, Sackler Faculty of Exact Sciences, Tel Aviv University, Ramat Aviv 69978, Israel
[3] School of Physics and Astronomy, Sackler Faculty of Exact Sciences, Tel Aviv University, Ramat Aviv 69978, Israel
Received 2010 May 20; accepted 2010 September 16; published 2010 November 22

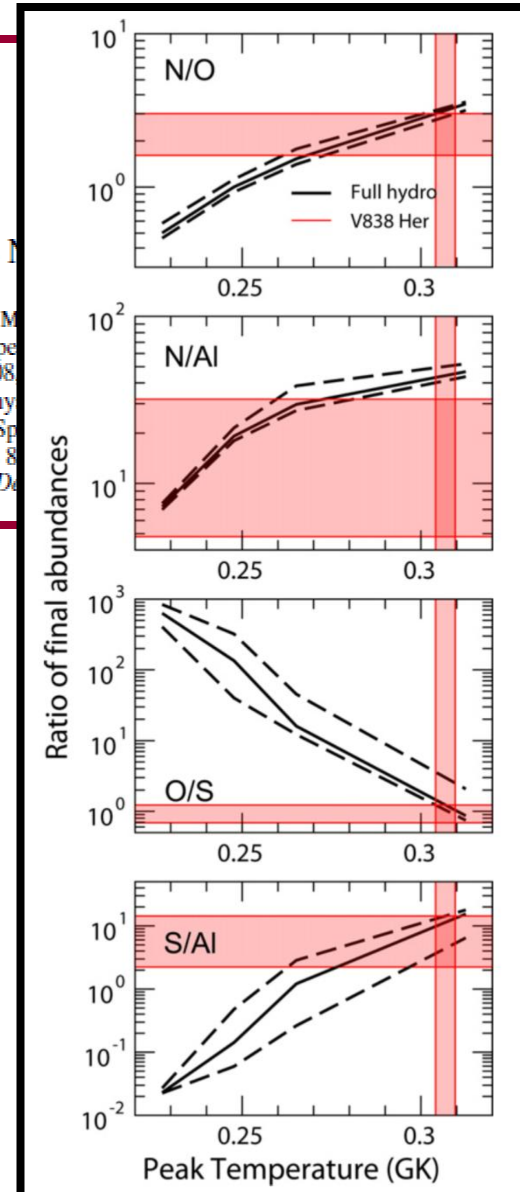
The Astrophysical Journal, 762:105 (11pp), 2013 January 10

NUCLEAR THERMOMETERS FOR CLASSICAL N

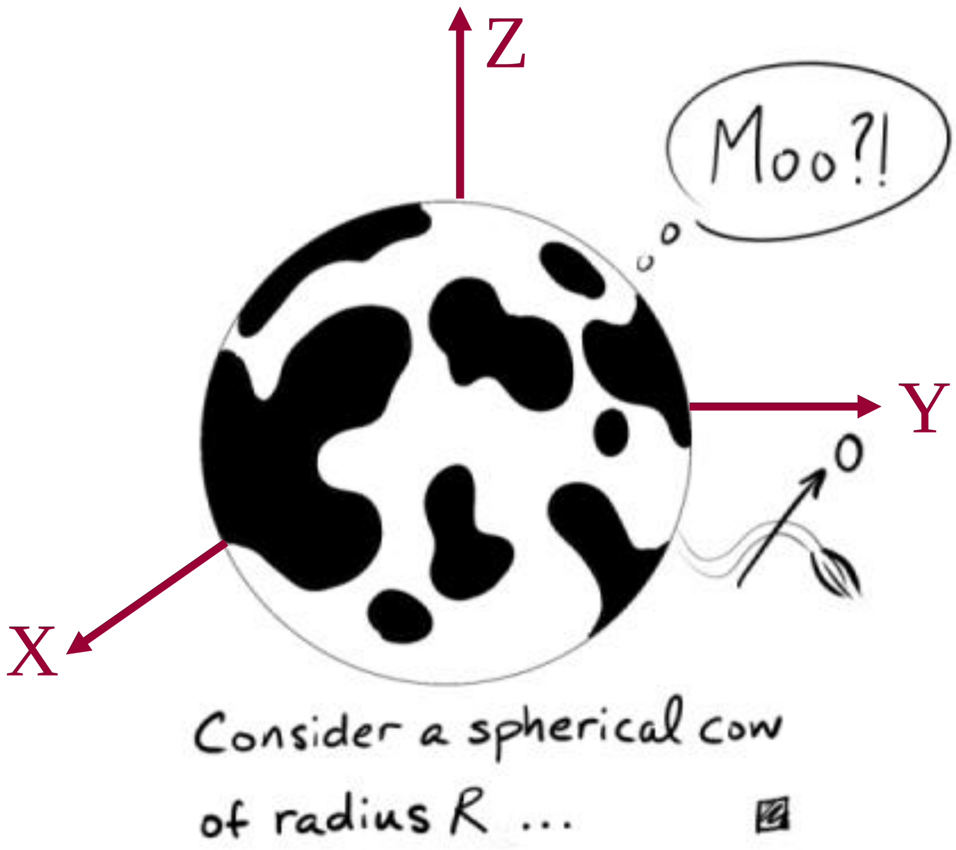
Lori N. Downen[1,2], Christian Iliadis[1,2], Jordi José[3,4], and Sum
[1] Department of Physics and Astronomy, University of North Carolina at Chapel Hill, Chape
[2] Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308
[3] Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Cataluny
[4] Institut d'Estudis Espacials de Catalunya, E-08034 Barcelona, Sp
[5] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 8
Received 2012 March 20; accepted 2012 November 14; published 2012 De



V838 Her



Multidimensional Models



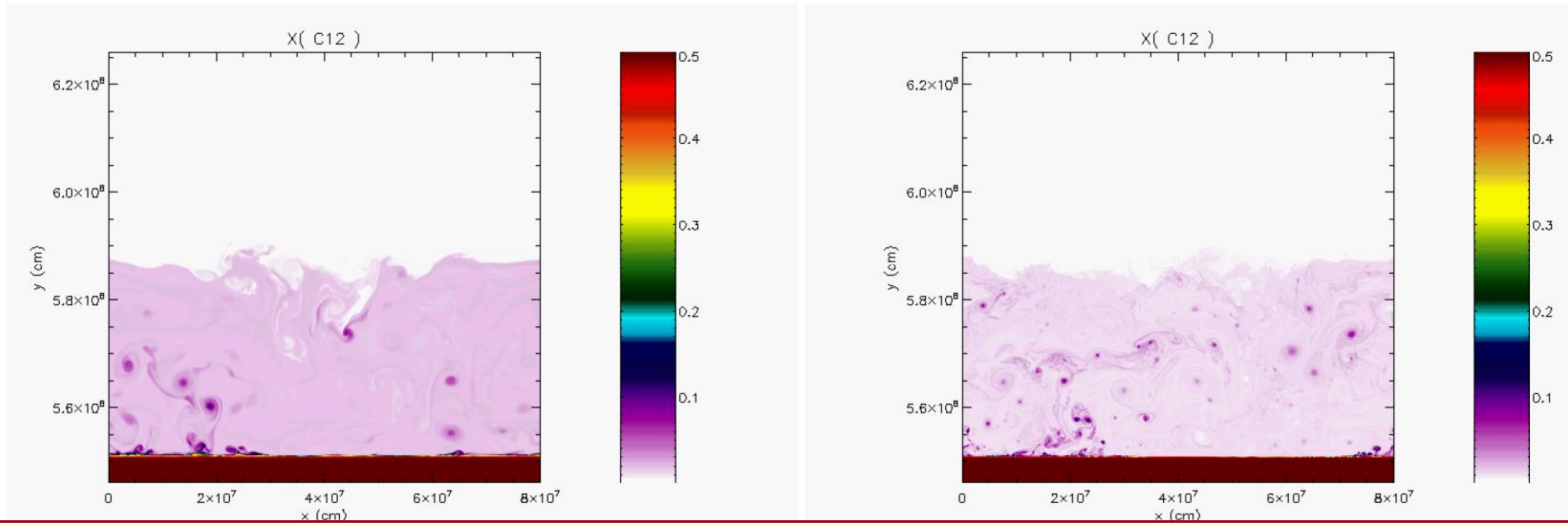
A&A 527, A5 (2011)
DOI: 10.1051/0004-6361/201015895

Astronomy & Astrophysics

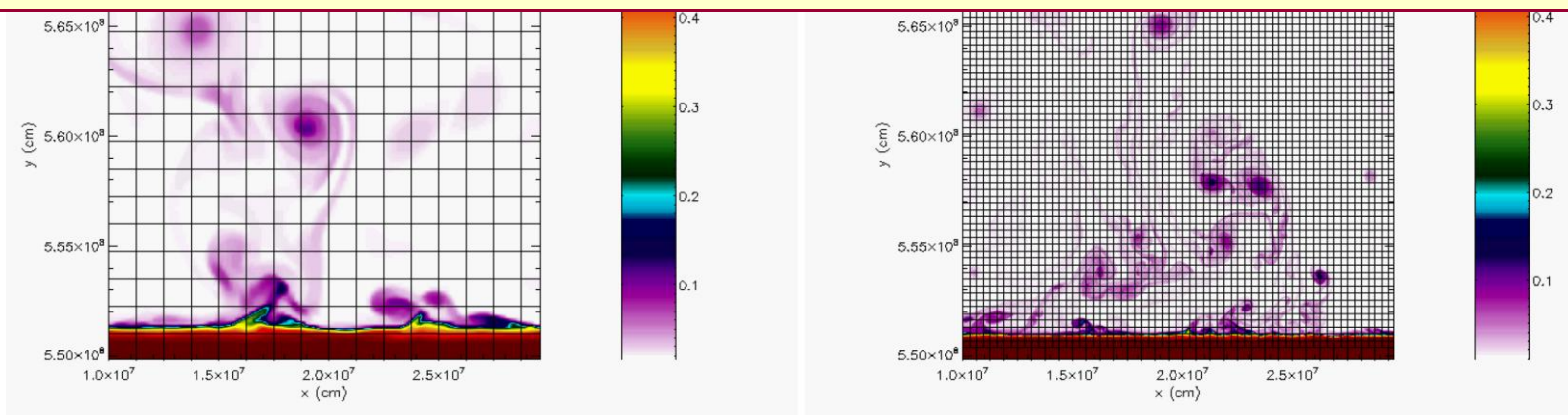
Mixing in classical novae: a 2-D sensitivity study★

J. Casanova[1,2], J. José[1,2], E. García-Berro[3,2], A. Calder[4], and S. N. Shore[5]

Model	H (km)	$R_x \times R_y$ (km)	δT	δt (s)	Resolution (km)	Computational Domain (km)	$t_{\rm KH}$ (s)	t_Y (s)	Z
A	0	1 × 1	5%	10^{-10}	1.56 × 1.56	800 × 800	155	496	0.224
B	0	1 × 1	5%	10	1.56 × 1.56	800 × 800	28	347	0.212
C	0	1 × 1	0.5%	10^{-10}	1.56 × 1.56	800 × 800	155	493	0.209
D	5	1 × 1	5%	10^{-10}	1.56 × 1.56	800 × 800	154	496	0.235
E	5	5 × 5	5%	10^{-10}	1.56 × 1.56	800 × 800	156	486	0.209
F	0	2 × 1	5%	10^{-10}	1.56 × 1.56	1600 × 800	151	493	0.206
G	0	1 × 1.25	5%	10^{-10}	1.56 × 1.56	800 × 1000	156	526	0.291
H	0	1 × 1	5%	10^{-10}	1 × 1	800 × 800	162	584	0.201
I	0	1 × 1	5%	10^{-10}	0.39 × 0.39	800 × 800	268	893	0.205



Results are **independent** of the specific choice of the **initial perturbation** (duration, strength, location, and size), **the resolution adopted**, or the **size of the computational domain**



Glasner, Livne & Truran (2012), MNRAS

2-D simulations for a wide range of possible compositions of the layer underlying the accreted envelope: **non-carbon cases**

Computational domain: $0.1\pi^{rad}$, as in GLT97
Resolution: 1.4×1.4 km^2

15 isotope network [up to ^{17}F]

All simulations involve a 1.147 M_o WD, with different substrates:

* CO
* He [recurrent novae]
* ONe → pure ^{16}O
* pure ^{24}Mg

3D Models of Mixing

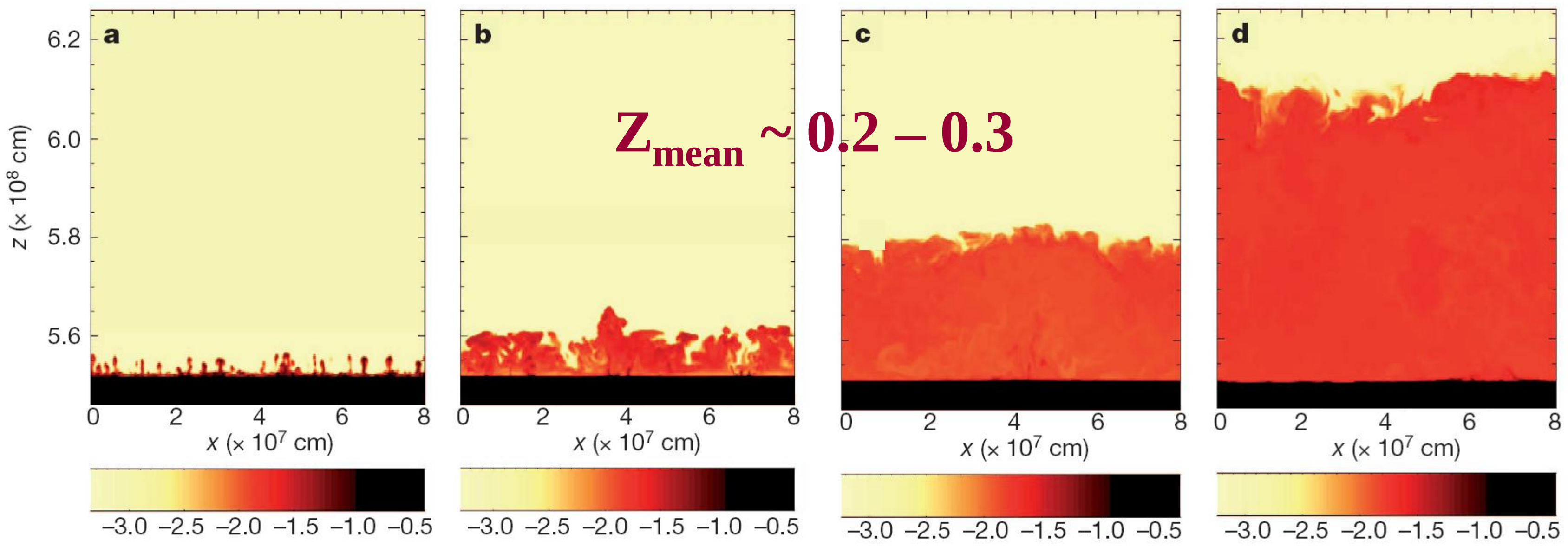
LETTER

doi:10.1038/nature10520

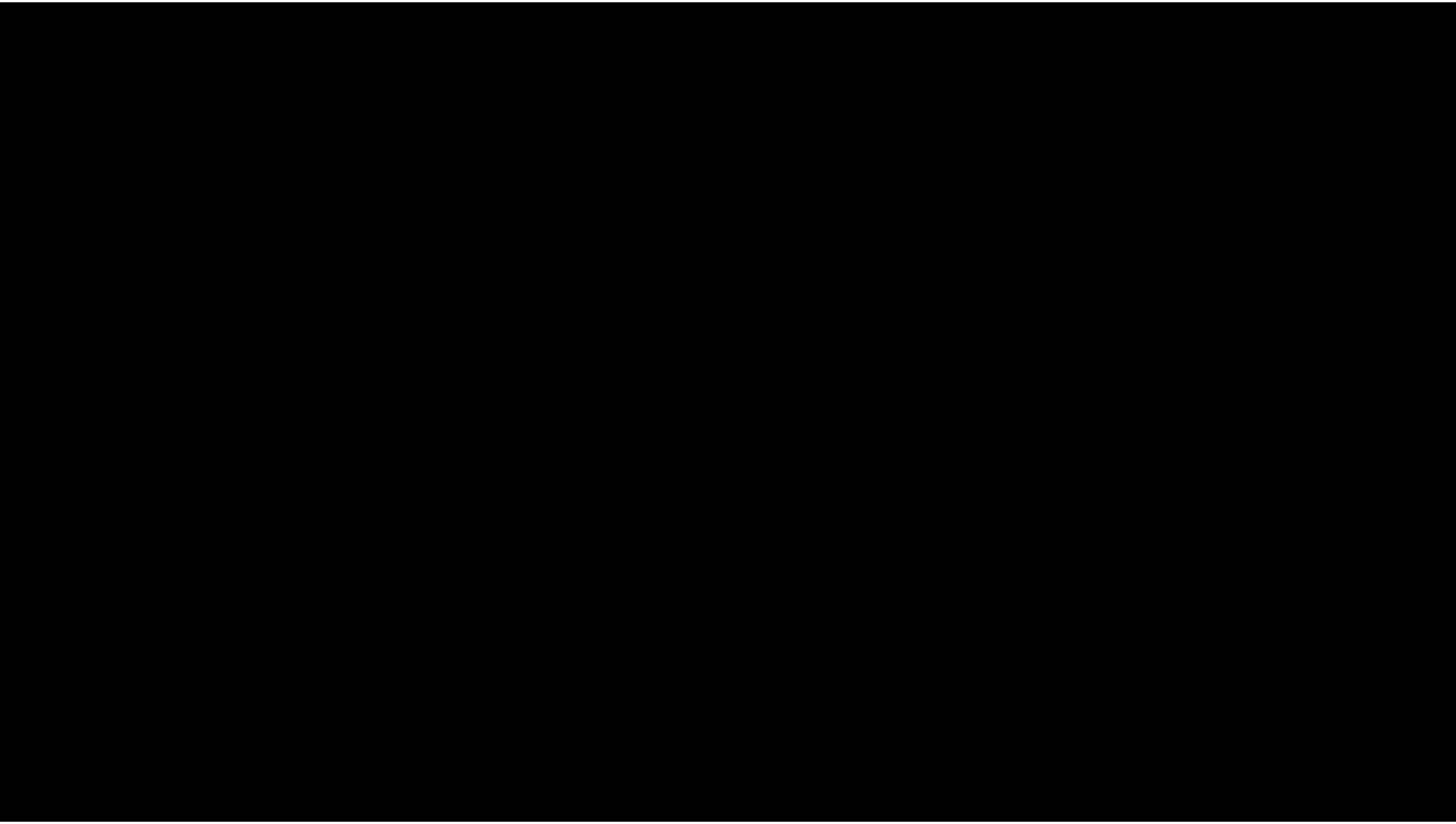
Kelvin–Helmholtz instabilities as the source of inhomogeneous mixing in nova explosions

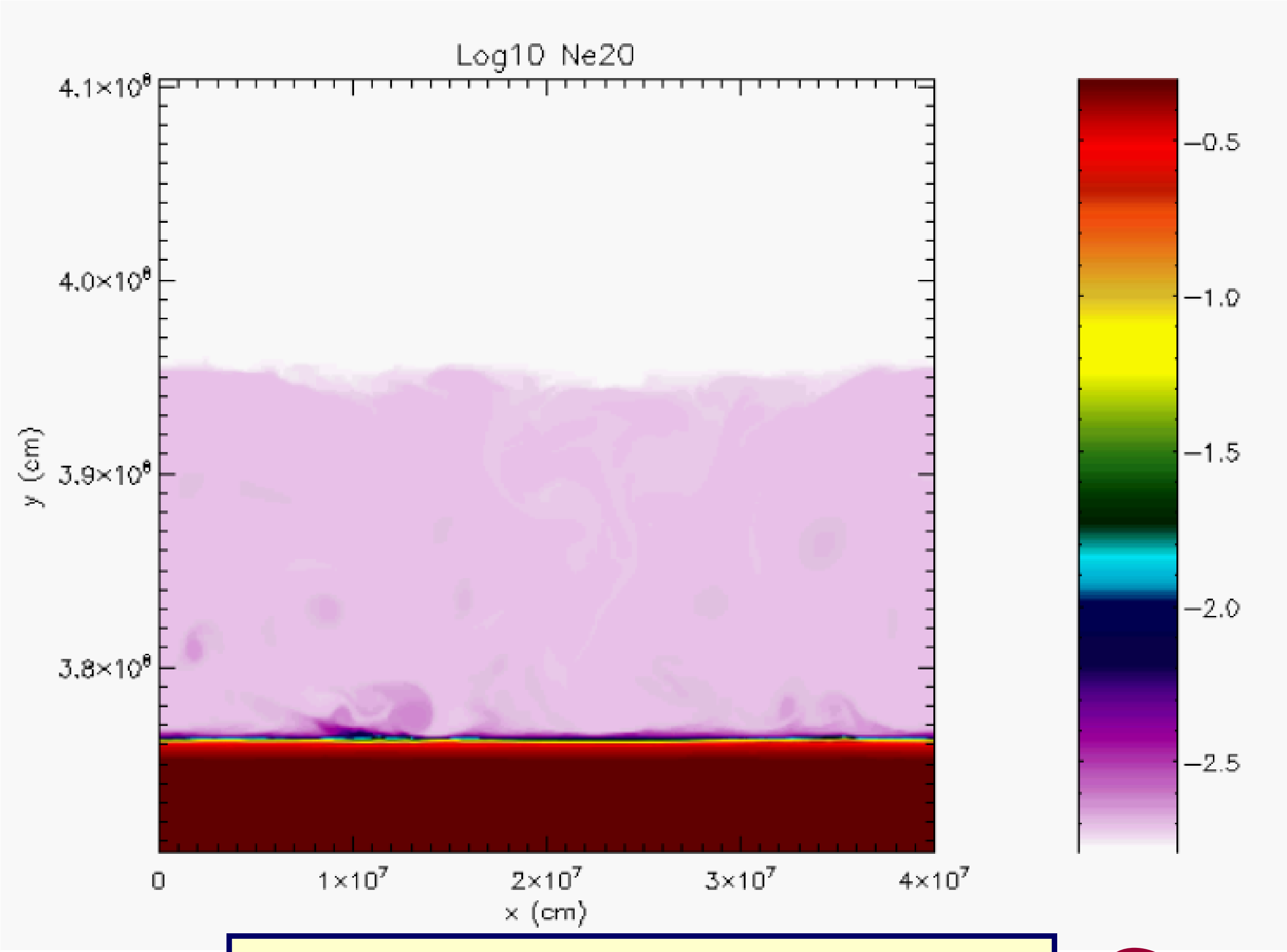
Jordi Casanova[1,2], Jordi José[1,2], Enrique García-Berro[3,2], Steven N. Shore[4] & Alan C. Calder[5]

€



$Z_{mean} \sim 0.2 – 0.3$

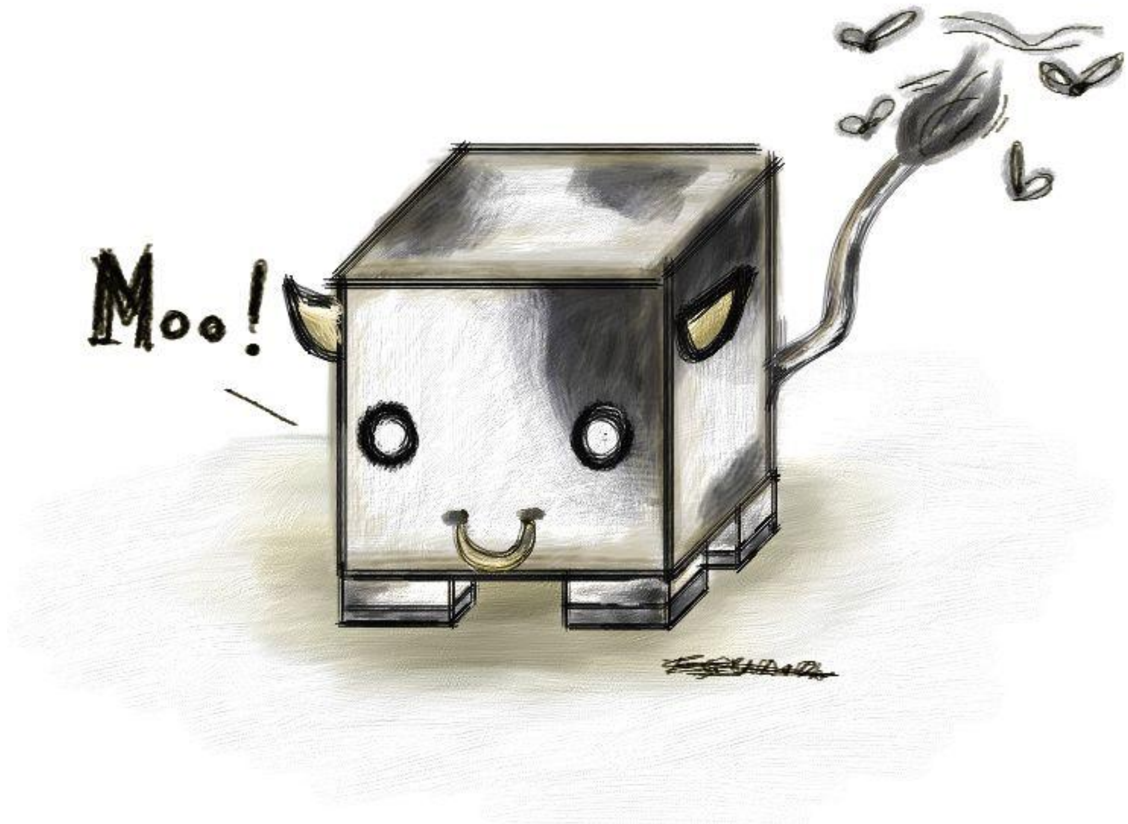




3D Model of mixing in an ONe nova.
Casanova et al. (2013), in preparation

€

From the spherical cow to the... cubic cow!

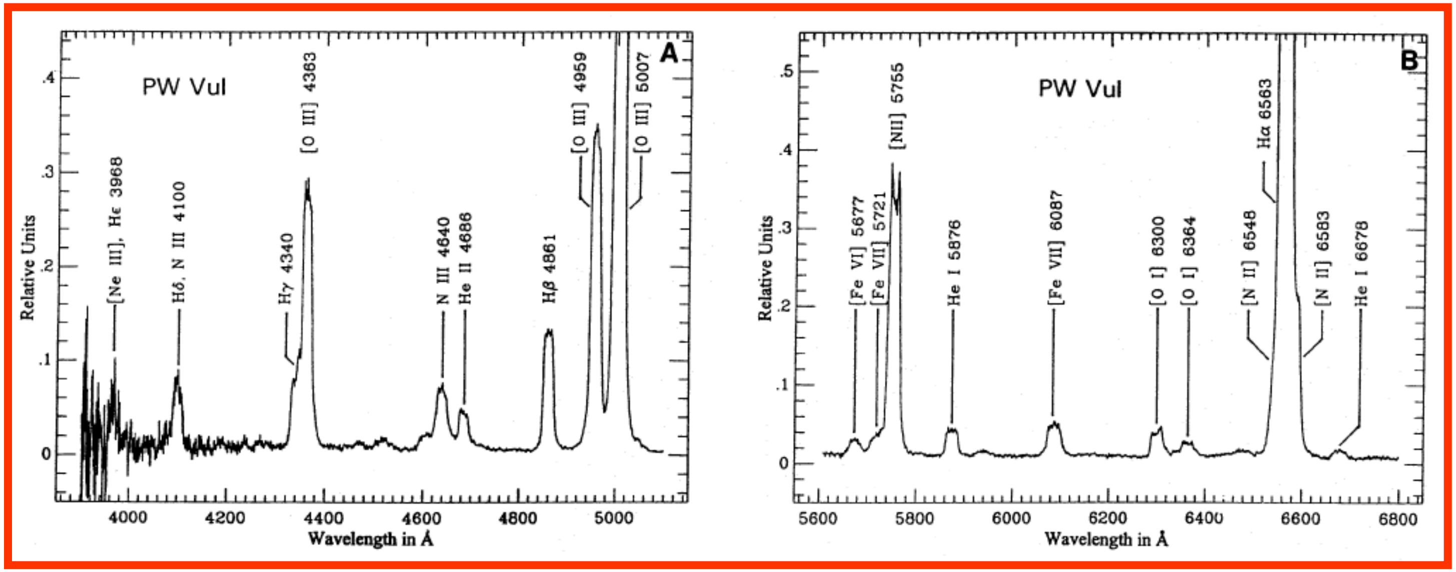


Joke adapted
from **T. O'Brien**


MareNostrum II (BSC, 2006), 94.21 Tflops/s, 10,240 processors

MareNostrum III (BSC, Jan. 2013), >1 Petaflop/s, 48,000 processors
[6,000 Intel SandyBridge chips (2,6 GHz), each with 8 cores]


Observational constraints



Andrëa et al. (1994)

PW Vul 1984

	H	He	C	N	O	Ne	Na-Fe	**Z**
Observation	0.47	0.23	0.073	0.14	0.083	0.0040	0.0048	0.30
Theory	0.47	0.25	0.073	0.094	0.10	0.0036	0.0037	0.28

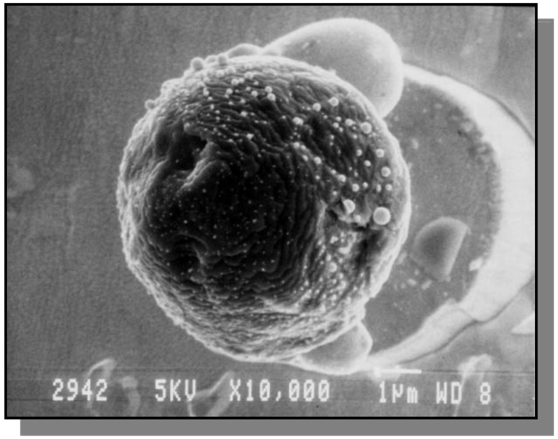
(JJ & Hernanz 1998)

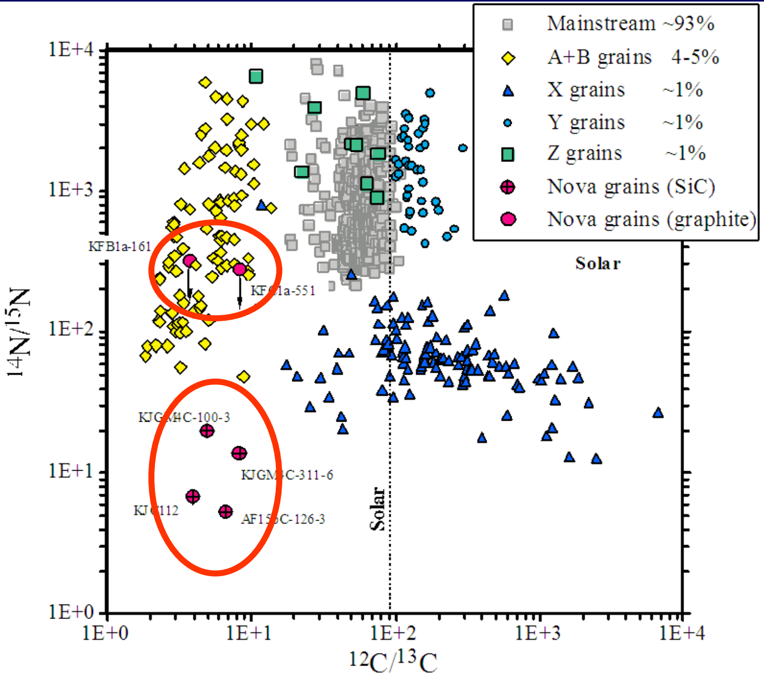
Presolar Grains

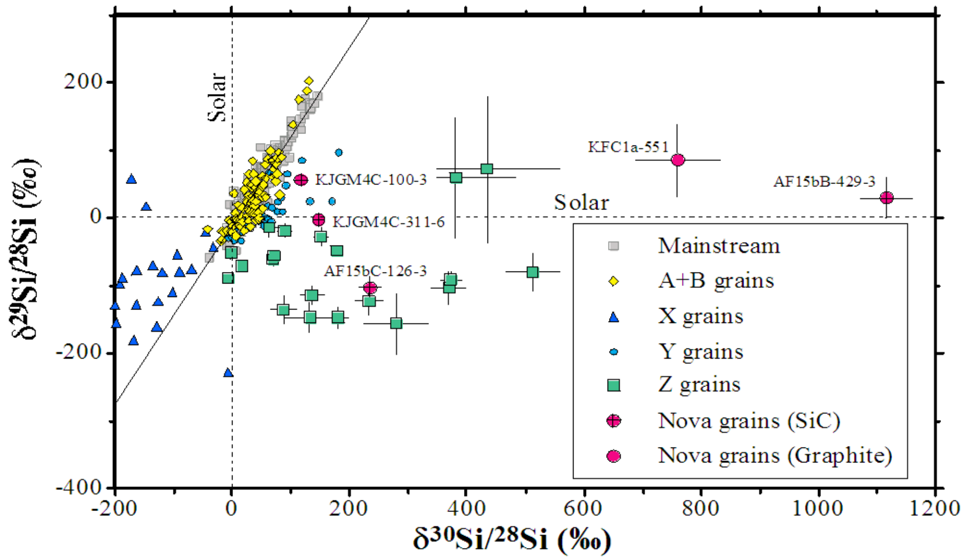
The Astrophysical Journal, 551:1065–1072, 2001 April 20

PRESOLAR GRAINS FROM NOVAE

Sachiko Amari, Xia Gao,[1] Larry R. Nittler,[2] and Ernst Zinner
Laboratory for Space Sciences and the Physics Department, Washington University, St. Louis, MO 63130-4899; sa@howdy.wustl.edu, ekz@howdy.wustl.edu
Jordi José[3] and Margarita Hernanz
Institut d'Estudis Espacials de Catalunya (IEEC/CSIC), E-08034 Barcelona, Spain; jjose@ieec.fcr.es, hernanz@ieec.fcr.es
and
Roy S. Lewis
Enrico Fermi Institute, University of Chicago, Chicago, IL 60637-1433; r-lewis@uchicago.edu
Received 2000 September 15; accepted 2000 December 18







The Astrophysical Journal, 742:86 (15pp), 2011 December 1 doi:10.1088/0004-637X/742/2/86

PRESOLAR GRAINS FROM NOVAE: EVIDENCE FROM NEON AND HELIUM ISOTOPES IN COMET DUST COLLECTIONS

Robert O. Pepin[1], Russell L. Palma[1,2], Robert D. Gehrz[3], and Sumner Starrfield[4]
[1] Department of Physics, University of Minnesota, Minneapolis, MN 55455, USA; pepin001@umn.edu
[2] Department of Physics and Astronomy, Minnesota State University, Mankato, MN 56001, USA
[3] Department of Astronomy, University of Minnesota, Minneapolis, MN 55455, USA
[4] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA
Received 2011 March 2; accepted 2011 August 12; published 2011 November 9

42nd Lunar and Planetary Science Conference (2011) €€ **2675.pdf**

NEW REACTION RATES AND IMPLICATIONS FOR NOVA NUCLEOSYNTHESIS AND PRESOLAR GRAINS. F. Gyngard[1], L. R. Nittler[1], E. Zinner[2], J. Jose[3], S. Cristallo[4], [1] Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road NW, Washington, DC 20015, USA, fgyngard@dtm.ciw.edu, [2]Laboratory for Space Sciences and Department of Physics, Washington University, St. Louis, MO 63130, USA, [3]Dept. Fisica i Enginyeria Nuclear, Universitat Politecnica de Catalunya & Institut d'Estudis Espacials de Catalunya, Barcelona, Spain, [4]Dept. de Fisica Teorica y del Cosmos, Universidad de Granada, Granada, Spain.

PROCEEDINGS OF SCIENCE

€€

Oxygen-rich Stardust Grains from Novae

Frank Gyngard[1]
Department of Terrestrial Magnetism, Carnegie Institution of Washington
5241 Broad Branch Road NW, Washington, DC 20015, USA
E-mail: `fgyngard@dtm.ciw.edu`

Larry R. Nittler
Department of Terrestrial Magnetism, Carnegie Institution of Washington
5241 Broad Branch Road NW, Washington, DC 20015, USA
E-mail: `lnittler@ciw.edu`

Ernst Zinner
Laboratory for Space Sciences and Physics Department, Washington University
1 Brookings Drive, St. Louis, MO 63130 USA
E-mail: `ekz@wustl.edu`

Jordi Jose
Dept. Fisica i Enginyeria Nuclear, Universitat Politecnica de Catalunya & Institut d'Estudis Espacials de Catalunya
Barcelona, Spain
E-mail: `jordi.jose@upc.edu`

γ-Ray Emission from Classical Novae

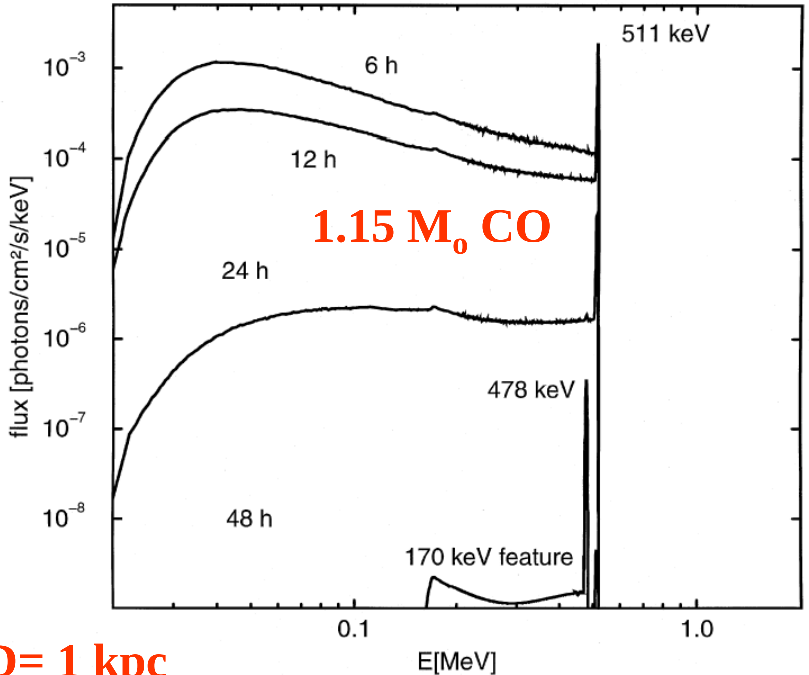
Isotope	Lifetime	Disintegration	Nova type
^{17}F	93 sec	β^+-decay	CO & ONe
^{14}O	102 sec	β^+-decay	CO & ONe
^{15}O	176 sec	β^+-decay	CO & ONe
^{13}N	862 sec	β^+-decay	CO & ONe
^{18}F	158 min	β^+-decay	CO & ONe
^{7}Be	77 day	e^--capture	CO
^{22}Na	3.75 yr	β^+-decay	ONe
^{26}Al	1.0 Myr	β^+-decay	ONe

* ^{14,15}O, ^{17}F (^{13}N): **Expansion and ejection stages**
* ^{13}N, ^{18}F: **Early** gamma-ray emission (**511 keV** plus continuum)
* ^{7}Be, ^{22}Na, ^{26}Al: Gamma-ray **lines**

^{18}F

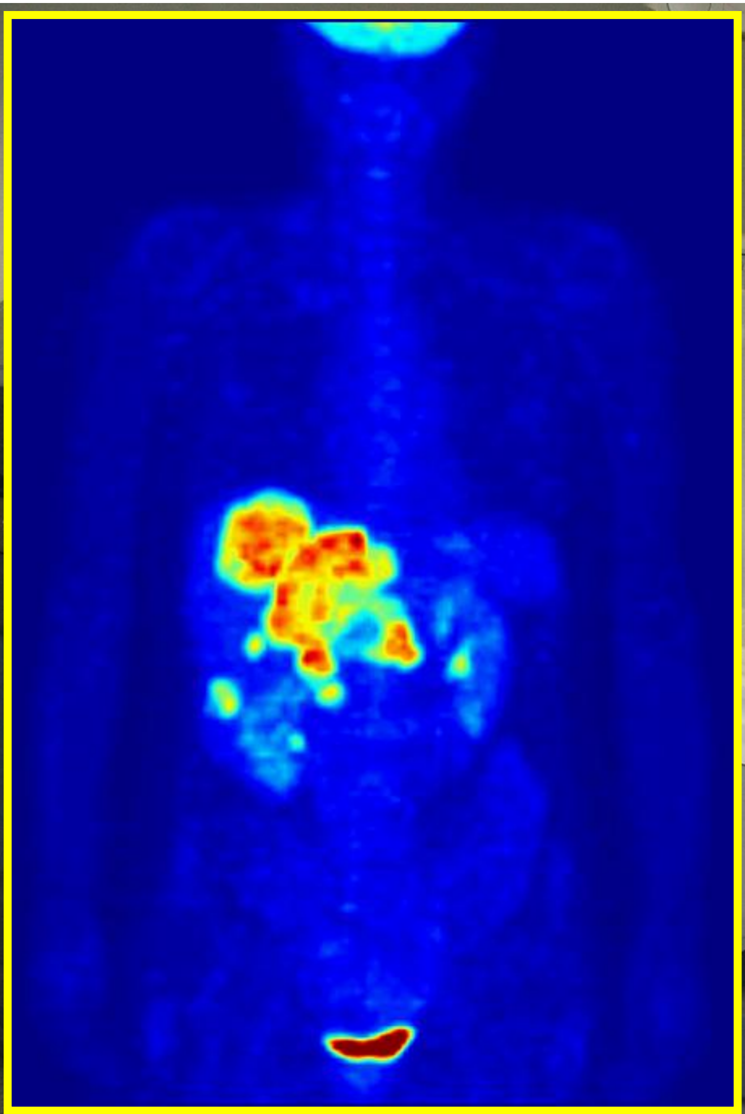
* **γ-ray signature**: ^{18}F decay ($T_{1/2}$ ~ **110 min**) provides a source of gamma-ray emission at **511 keV and below** (related to electron-positron annihilation).

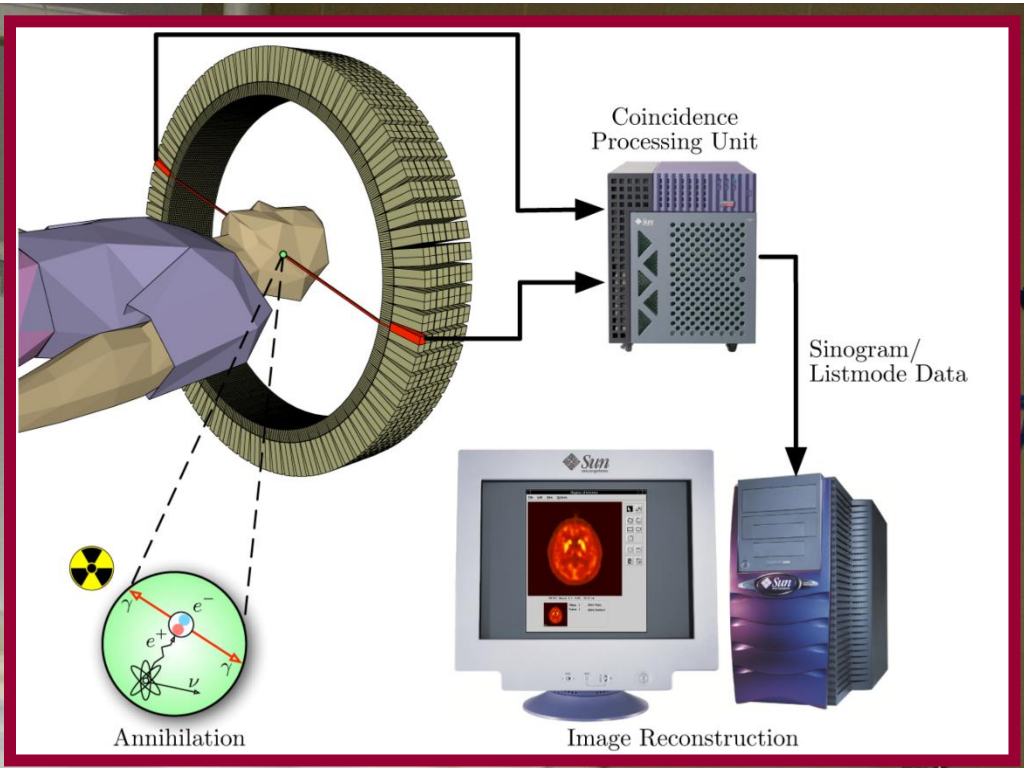
But! **Uncertainties** in the rates translate into a factor **~ 5 - 10** uncertainty in the expected fluxes!



D= 1 kpc

Gómez-Gomar, Hernanz, JJ, & Isern (1998), MNRAS





Positron Emission Tomography (**PET**)

Bull. Astr. Soc. India (2012) **40**, 377–391

Novae in γ-rays €

M. Hernanz*

Hernanz's talk, this Conference

4th Fermi Symposium : Monterey, CA : 28 Oct-2 Nov 2012

Fermi Discovers a New Population of Gamma-ray Novae

C.C. Cheung
Space Science Division, Naval Research Laboratory, Washington, DC 20375, USA
on behalf of the Fermi-LAT Collaboration

Imaging detector development for nuclear astrophysics using pixelated CdTe

J.M. Álvarez [a,*], J.L. Gálvez [a], M. Hernanz [a], J. Isern [a], M. Llopis [a], M. Lozano [b], G. Pellegrini [b], M. Chmeissani [c]

[a] *Institut de Ciencies de l'Espai (CSIC-IEEC), Campus UAB, E-08193 Barcelona, Spain*
[b] *Centro Nacional de Microelectronica (IMB-CNM(CSIC)), Campus UAB, E-08193 Barcelona, Spain*
[c] *Institut de Física d'Altes Energies (IFAE), Campus UAB, E-08193 Barcelona, Spain*

THE ASTROPHYSICAL JOURNAL, 733:70 (16pp), 2011 May 20 doi:10.1088/0004-637X/733/1/70

XMM-NEWTON X-RAY AND ULTRAVIOLET OBSERVATIONS OF THE FAST NOVA V2491 Cyg DURING THE SUPERSOFT SOURCE PHASE

J.-U. NESS[1], J. P. OSBORNE[2], A. DOBROTKA[3,4], K. L. PAGE[2], J. J. DRAKE[5], C. PINTO[6], R. G. DETMERS[6], G. SCHWARZ[7], M. F. BODE[8], A. P. BEARDMORE[2], S. STARRFIELD[9], M. HERNANZ[10], G. SALA[11], J. KRAUTTER[12], AND C. E. WOODWARD[13]
[1] XMM-Newton Science Operations Centre, ESA, Madrid, Spain
[2] Department of Physics & Astronomy, University of Leicester, Leicester, LE1 7RH, UK
[3] Department of Physics, Institute of Materials Science, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, 91724 Trnava, Slovakia
[4] Department of Astronomy, Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[5] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
[6] SRON Netherlands Institute for Space Research, 3584 CA Utrecht, The Netherlands
[7] American Astronomical Society, Washington, DC 20009-1231, USA
[8] Astrophysics Research Institute, Liverpool John Moores University, Birkenhead CH41 1LD, UK
[9] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, USA
[10] Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Facultat de Ciències, 08193 Bellaterra (Barcelona), Spain
[11] Departament Física i Enginyeria Nuclear, EUETIB (UPC-IEEC), 08036 Barcelona, Spain
[12] Landessternwarte Königstuhl, Universität Heidelberg, D-69117 Heidelberg, Germany
[13] Department of Astronomy, University of Minnesota, Minneapolis, MN 55455, USA
Received 2010 November 7; accepted 2011 March 21; published 2011 May 5

€

THE ASTROPHYSICAL JOURNAL, 745:43 (16pp), 2012 January 20 doi:10.1088/0004-637X/745/1/43

FROM X-RAY DIPS TO ECLIPSE: WITNESSING DISK REFORMATION IN THE RECURRENT NOVA U Sco

J.-U. NESS[1], B. E. SCHAEFER[2], A. DOBROTKA[3,4], A. SADOWSKI[5], J. J. DRAKE[6], R. BARNARD[6], A. TALAVERA[1], R. GONZALEZ-RIESTRA[1], K. L. PAGE[7], M. HERNANZ[8], G. SALA[9], AND S. STARRFIELD[10]
[1] XMM-Newton Science Operations Centre, ESA, P.O. Box 78, 28691 Villanueva de la Cañada, Madrid, Spain; juness@sciops.esa.int
[2] Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803, USA
[3] Department of Physics, Institute of Materials Science, Faculty of Materials Science and Technology, Slovak University of Technology, Jána Bottu 25, 91724 Trnava, Slovakia
[4] Department of Astronomy, Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[5] N. Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00-716 Warszawa, Poland
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[7] Department of Physics & Astronomy, University of Leicester, Leicester LE1 7RH, UK
[8] Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Facultat de Ciències, C5 parell 2on, 08193 Bellaterra (Barcelona), Spain
[9] Departament Física i Enginyeria Nuclear, EUETIB (UPC-IEEC), Comte d'Urgell 187, 08036 Barcelona, Spain
[10] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, USA
Received 2011 May 12; accepted 2011 November 4; published 2011 December 28

€

A&A 523, A89 (2010)
DOI: 10.1051/0004-6361/201014710

Astronomy & Astrophysics

X-ray monitoring of classical novae in the central region of M 31

I. June 2006–March 2007*

M. Henze[1], W. Pietsch[1], F. Haberl[1], M. Hernanz[2], G. Sala[3], M. Della Valle[4,5,6], D. Hatzidimitriou[7,8], A. Rau[1,9], D. H. Hartmann[10], J. Greiner[1], V. Burwitz[1], and J. Fliri[11,12,13]

1 Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, 85748 Garching, Germany
e-mail: mhenze@mpe.mpg.de
2 Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Fac. Ciències, 08193 Bellaterra, Spain
3 Departament de Física i Enginyeria Nuclear, EUETIB (UPC-IEEC), Comte d'Urgell 187, 08036 Bar
4 European Southern Observatory (ESO), 85748 Garching, Germany
5 INAF-Napoli, Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy
6 International Centre for Relativistic Astrophysics, Piazzale della Repubblica 2, 65122 Pescara, Italy
7 Department of Astrophysics, Astronomy and Mechanics, Faculty of Physics, University of Athens, P
15784 Zografos, Athens, Greece
8 Foundation for Research and Technology Hellas, IESL, Greece
9 California Institute of Technology, Pasadena, CA 91125, USA
10 Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-0978, USA
11 Universitätssternwarte München, Scheinerstrasse, 81679 München, Germany
12 Instituto de Astrofisica de
13 Departamento de Astrofis

A&A 531, A22 (2011)
DOI: 10.1051/0004-6361/201116756

Astronomy & Astrophysics

Nova M31N 2007-12b: supersoft X-rays reveal an intermediate polar?*

W. Pietsch[1], M. Henze[1], F. Haberl[1], M. Hernanz[2], G. Sala[3], D. H. Hartmann[4], and M. Della Valle[5,6,7]

chstraße, 85741 Garching, Germany
Fac. Ciències, 08193 Bellatera, Spain
-IEEC), Comte d'Urgell 187, 08036 Barcelona, Spain
Clemson, SC 29634-0978, USA
rmany
Salita Moiariello 16, 80131 Napoli, Italy
lella Repubblica 2, 65122 Pescara, Italy

A&A 533, A52 (2011)
DOI: 10.1051/0004-6361/201015887

Astronomy & Astrophysics

X-ray monitoring of classical novae in the central region of M 31

II. Autumn and winter 2007/2008 and 2008/2009*,**,***

M. Henze[1], W. Pietsch[1], F. Haberl[1], M. Hernanz[2], G. Sala[3], D. Hatzidimitriou[4,5], M. Della Valle[6,7,8], A. Rau[1], D. H. Hartmann[9], and V. Burwitz[1]

1 Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, 85748 Garching, Germany
e-mail: mhenze@mpe.mpg.de
2 Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Fac. Ciències, 08193 Bellaterra, Spain
3 Departament de Física i Enginyeria Nuclear, EUETIB (UPC-IEEC), Comte d'Urgell 187, 08036 Barcelona, Spain
4 Department of Astrophysics, Astronomy and Mechanics, Faculty of Physics, University of Athens, Panepistimiopolis, 15784 Zografos, Athens, Greece
5 Foundation for Research and Technology Hellas, IESL, Greece
6 European Southern Observatory (ESO), 85748 Garching, Germany
7 INAF-Napoli, Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy
8 International Centre for Relativistic Astrophysics, Piazzale della Repubblica 2, 65122 Pescara, Italy
9 Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-0978, USA

Exp Astron (2012) 34:415–444
DOI 10.1007/s10686-011-9237-2

ORIGINAL ARTICLE

The Large Observatory for X-ray Timing (LOFT)

M. Feroci · L. Stella · M. van der Klis · T. J.-L. Courvoisier · M. Hernanz · R. Hudec · A. Santangelo · D. Walton · A. Zdziarski · D. Barret · T. Belloni · J. Braga · S. Brandt · C. Budtz-Jørgensen · S. Campana · J.-W. den Herder · J. Huovelin · G. L. Israel · M. Pohl · P. Ray · A. Vacchi · S. Zane · A. Argan · P. Attinà · G. Bertuccio · E. Bozzo · R. Campana · D. Chakrabarty · E. Costa · A. De Rosa · E. Del Monte · S. Di Cosimo · I. Donnarumma · Y. Evangelista · D. Haas · P. Jonker · S. Korpela · C. Labanti · P. Malcovati · R. Mignani · F. Muleri · M. Rapisarda · A. Rashevsky · N. Rea · A. Rubini · C. Tenzer · C. Wilson-Hodge · B. Winter · K. Wood · G. Zampa · N. Zampa · M. A. Abramowicz · M. A. Alpar · D. Altamirano · J. M. Alvarez · L. Amati · C. Amoros · L. A. Antonelli · R. Artigue · P. Azzarello · M. Bachetti · G. Baldazzi · M. Barbera · C. Barbieri · S. Basa · A. Baykal · R. Belmont · L. Boirin · V. Bonvicini · L. Burderi · M. Bursa · C. Cabanac · E. Cackett · G. A. Caliandro · P. Casella · S. Chaty · J. Chenevez · M. J. Coe · A. Collura · A. Corongiu · S. Covino · G. Cusumano · F. D'Amico · S. Dall'Osso · D. De Martino · G. De Paris · G. Di Persio · T. Di Salvo · C. Done · M. Dovčiak · A. Drago · U. Ertan · S. Fabiani · M. Falanga · R. Fender · P. Ferrando · D. Della Monica Ferreira · G. Fraser · F. Frontera · F. Fuschino · J. L. Galvez · P. Gandhi · P. Giommi · O. Godet · E. Göğüş · A. Goldwurm · D. Götz · M. Grassi · P. Guttridge · P. Hakala · G. Henri · W. Hermsen · J. Horak · A. Hornstrup · J. J. M. in 't Zand · J. Isern · E. Kalemci · G. Kanbach · V. Karas · D. Kataria · T. Kennedy · D. Klochkov · W. Kluźniak · K. Kokkotas · I. Kreykenbohm · J. Krolik · L. Kuiper · I. Kuvvetli · N. Kylafis · J. M. Lattimer · F. Lazzarotto · D. Leahy · F. Lebrun · D. Lin · N. Lund · T. Maccarone · J. Malzac · M. Marisaldi · A. Martindale · M. Mastropietro · J. McClintock · I. McHardy · M. Mendez · S. Mereghetti · M. C. Miller · T. Mineo · E. Morelli · S. Morsink · C. Motch · S. Motta · T. Muñoz-Darias · G. Naletto · V. Neustroev · J. Nevalainen · J. F. Olive · M. Orio · M. Orlandini · P. Orleanski · F. Ozel · L. Pacciani · S. Paltani · I. Papadakis · A. Papitto · A. Patruno · A. Pellizzoni · V. Petráček · J. Petri · P. O. Petrucci · B. Phlips · L. Picolli · A. Possenti · D. Psaltis · D. Rambaud · P. Reig · R. Remillard · J. Rodriguez · P. Romano · M. Romanova · T. Schanz · C. Schmid · A. Segreto · A. Shearer · A. Smith · P. J. Smith · P. Soffitta · N. Stergioulas · M. Stolarski · Z. Stuchlik · A. Tiengo · D. Torres · G. Török · R. Turolla · P. Uttley · S. Vaughan · S. Vercellone · R. Waters · A. Watts · R. Wawrzaszek · N. Webb · J. Wilms · L. Zampieri · A. Zezas · J. Ziolkowski

Received: 22 May 2011 / Accepted: 27 June 2011 / Published online: 2 August 2011

III. Type Ia Supernovae

Supernovae: the *Mother* of all Stellar Explosions

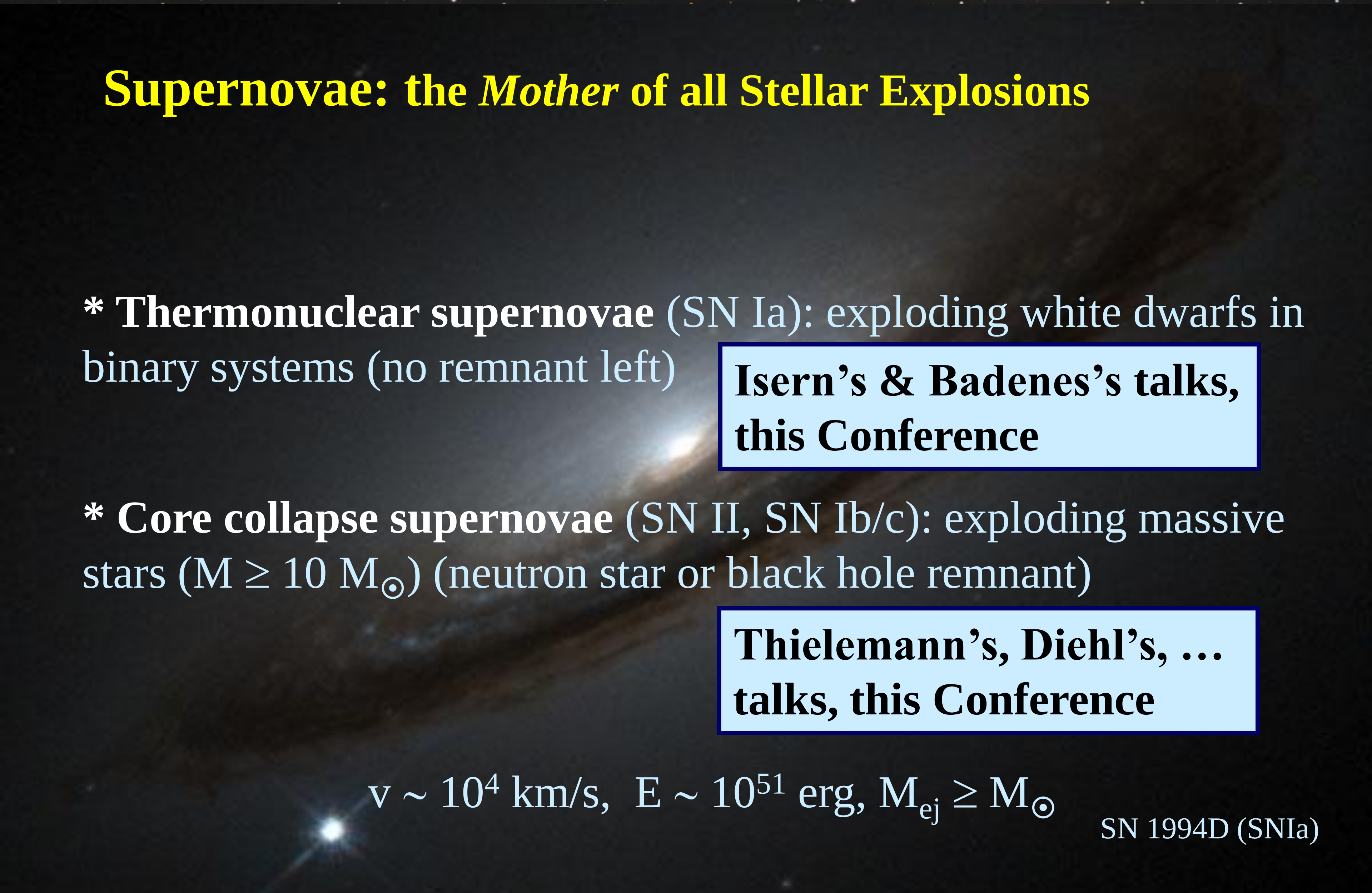
* **Thermonuclear supernovae** (SN Ia): exploding white dwarfs in binary systems (no remnant left)

Isern's & Badenes's talks, this Conference

* **Core collapse supernovae** (SN II, SN Ib/c): exploding massive stars ($M \geq 10\ M_\odot$) (neutron star or black hole remnant)

Thielemann's, Diehl's, … talks, this Conference

$v \sim 10^4$ km/s, $E \sim 10^{51}$ erg, $M_{ej} \geq M_\odot$



SN 1994D (SNIa)

Thermonuclear Supernovae

Defined by the lack of **H** and the presence of a prominent, blueshifted absorption **Si II** feature (around λ6150) in the spectrum

* **homogeneity:** ~70% of all **SN Ia** have similar spectra, light curves and peak absolute magnitudes: **unique progenitor????**

➡ thermonuclear disruption of **mass-accreting white dwarfs**

* Scenario: not fully understood

- Single degenerate scenario: **WD + ‘Normal’ companion** (H or He accretion)
- Double degenerate scenario: **WD + WD** (He or C-O accretion)

Ignition Mechanism

Central C-ignition in Chandrasekhar-mass WDs

$M_{CO} \sim 1.4\ M_{\odot}$

Detonation: supersonic flame

C,O $\not\rightarrow$ Ni

Deflagration: subsonic velocity

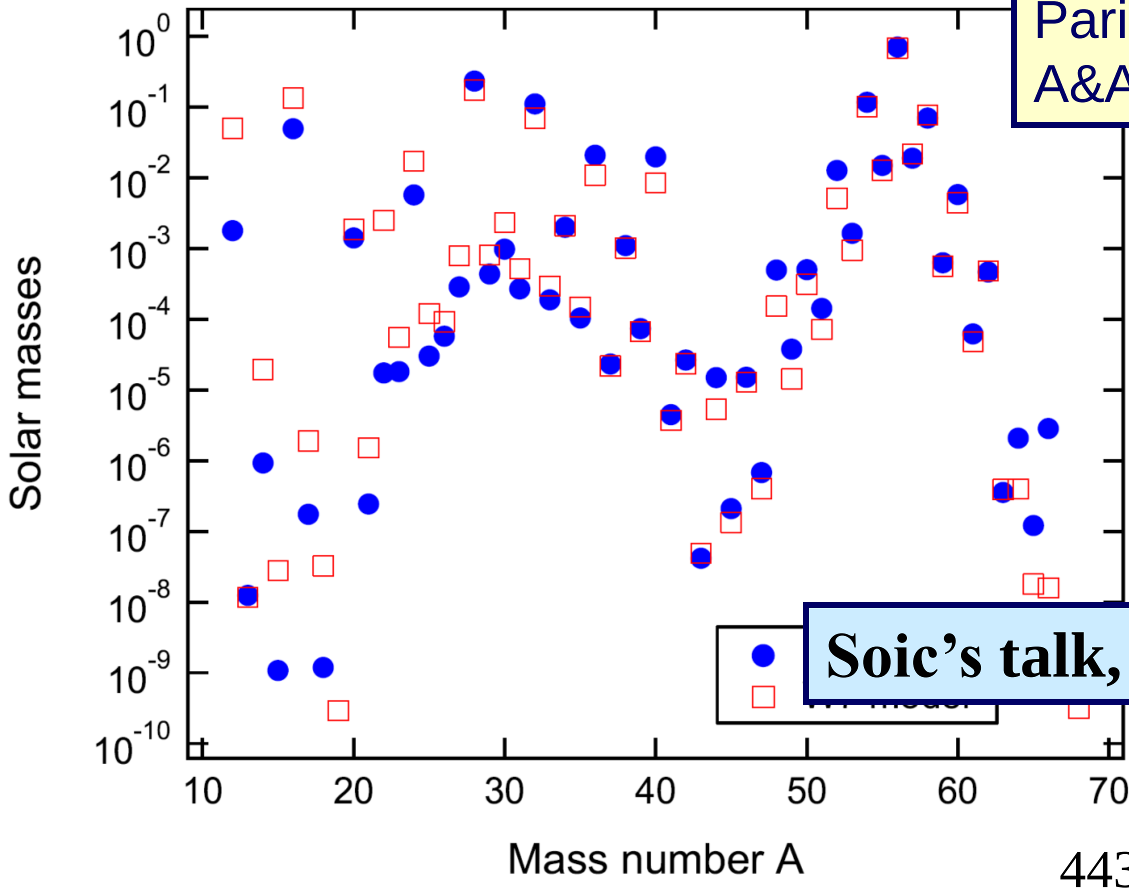
Deflagration ⟷ detonation:
Delayed detonation

Thermonuclear Supernovae: Nucleosynthesis

Supernovae are crucial for life... But never get too close!

Parikh, JJ, Seitenzahl & Röpke, A&A (2013), submitted

€€



Soic's talk, this Conference

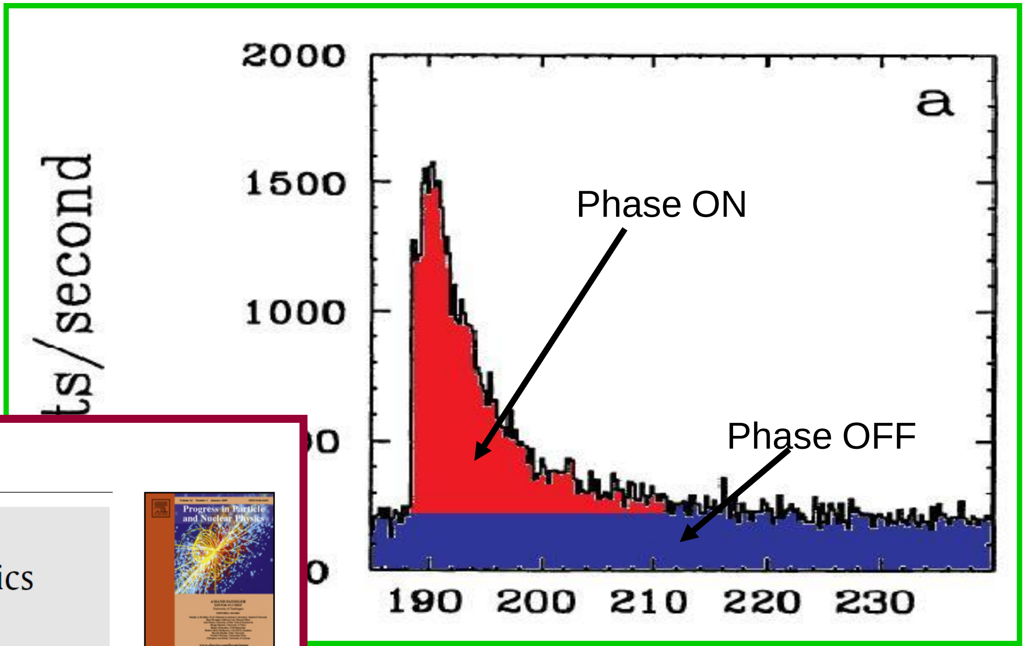
443 isotopes (H − Kr); 5267 links

IV. Type I X-Ray Bursts

First discovered in **1975** (Grindlay , Heise, et al. 1976) with the **ANS** (also Belian, Conner & Evans 1976: **Vela** satellites)

The Type I XRB ID Card

Very fast rise times: 2 – 10 s
Short duration: 10 – 100 s
L_{peak} ~ 10^{38} erg s^{-1}
Energy released: ~ 10^{39} erg
Recurrence time: ~ hours – days



) 4U 1820-30

i & Cavalieri'77; Joss'77

Progress in Particle and Nuclear Physics 69 (2013) 225–253
Contents lists available at SciVerse ScienceDirect
Progress in Particle and Nuclear Physics
journal homepage: www.elsevier.com/locate/ppnp
ELSEVIER

Review

Nucleosynthesis in type I X-ray bursts

A. Parikh [a,b,*], J. José [a,b], G. Sala [a,b], C. Iliadis [c,d]

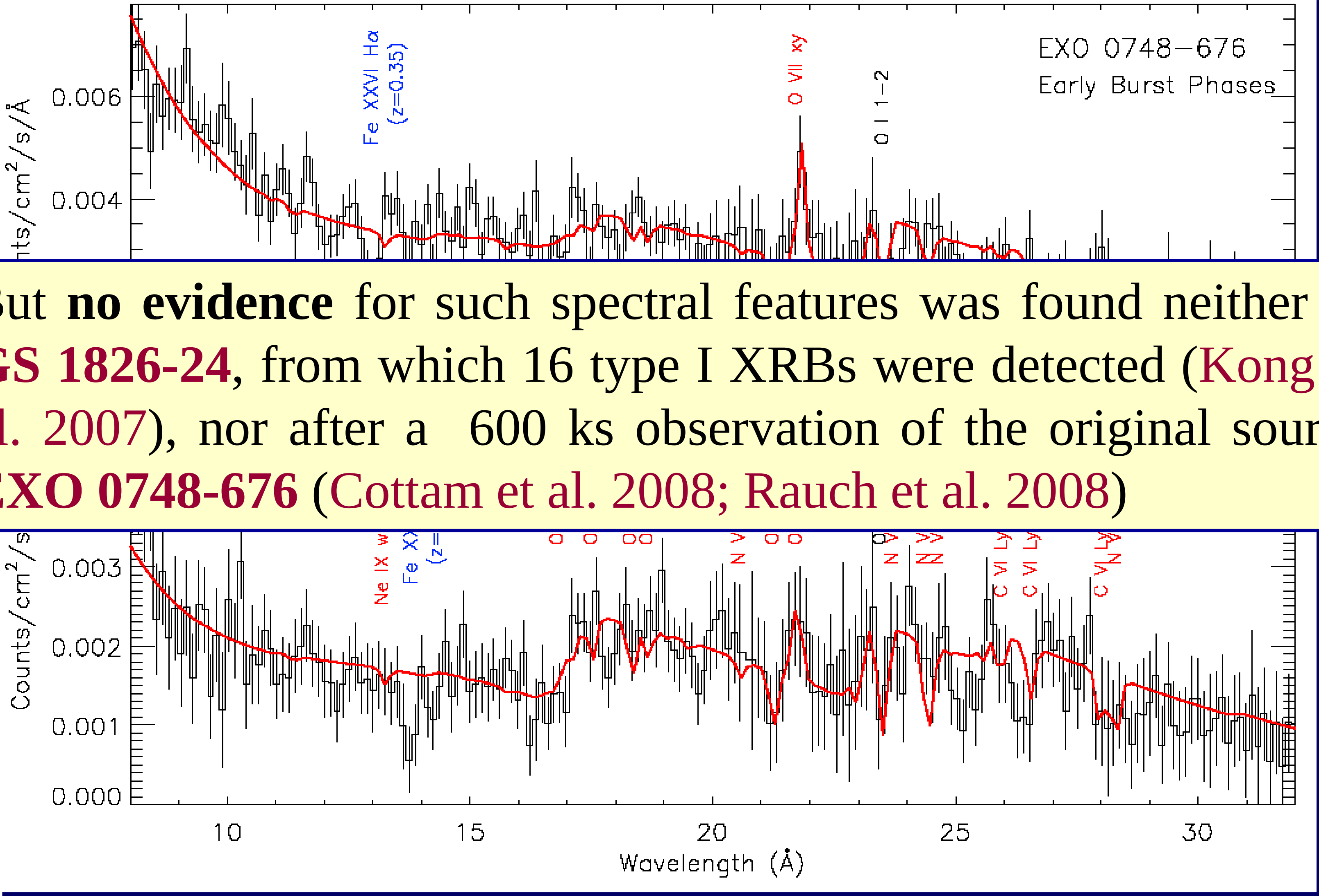
[a] *Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya (EUETIB), E-08036 Barcelona, Spain*
[b] *Institut d'Estudis Espacials de Catalunya (IEEC), E-08034 Barcelona, Spain*
[c] *Department of Physics and Astronomy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA*
[d] *Triangle Universities Nuclear Laboratory, Duke University, Durham, NC 27708, USA*

€€

The potential impact of XRB nucleosynthesis on **Galactic abundances** is still a matter of debate:

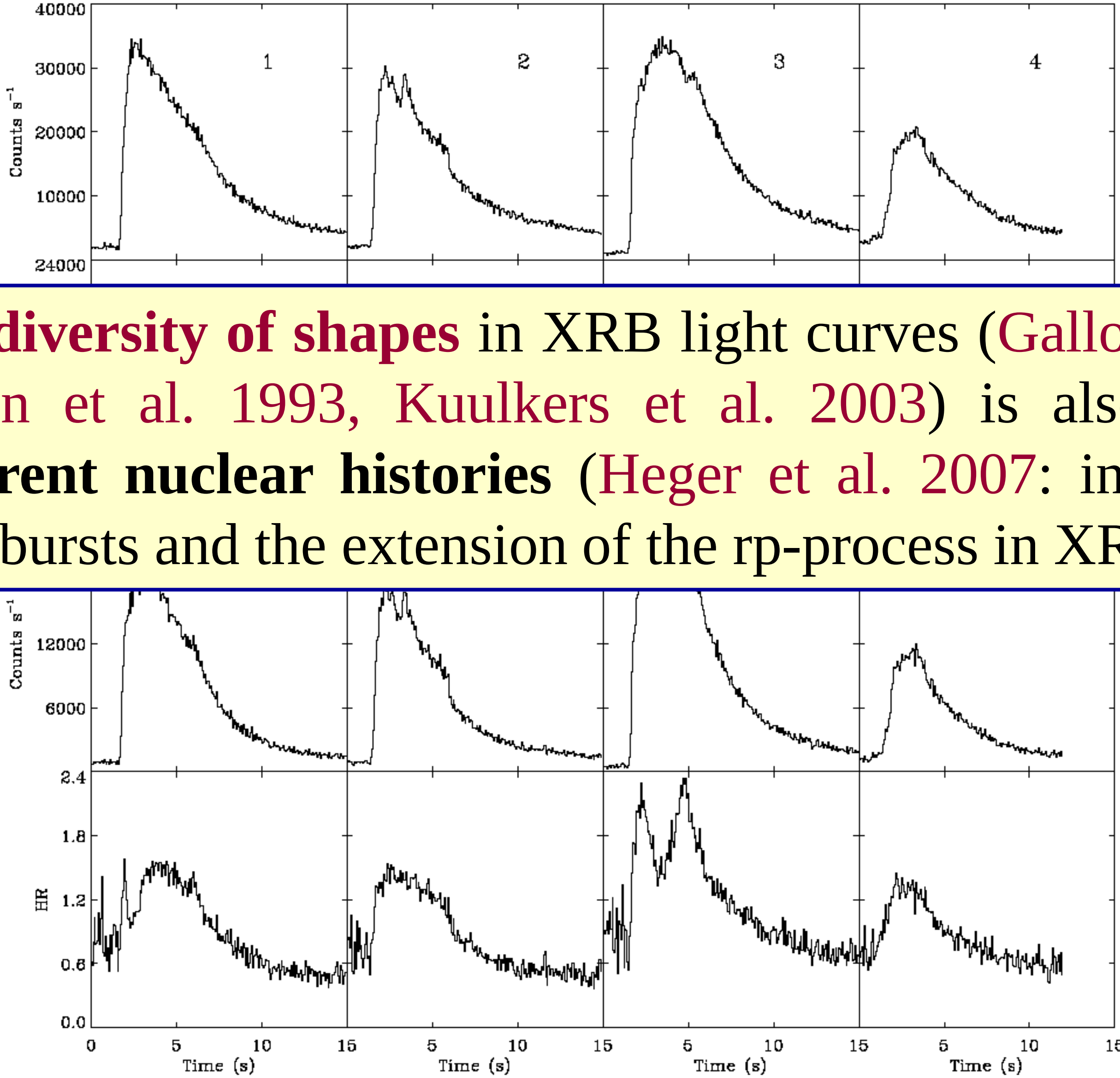
Ejection from a NS **unlikely** because of its large **gravitational potential** (ejection from the surface a NS of mass *M* and radius *R* requires GMm_p/R ~200 MeV/nucleon, whereas only a few MeV/nucleon are released from thermonuclear fusion)

However, it has been suggested that **radiation-driven winds** during photospheric radius expansion may lead to the ejection of a tiny fraction of the envelope (Weinberg et al. 2006a). Indeed, it has been suggested that XRBs might account for the Galactic abundances of the problematic light ***p-nuclei*** (Schatz et al. 1998)



But **no evidence** for such spectral features was found neither in **GS 1826-24**, from which 16 type I XRBs were detected (Kong et al. 2007), nor after a 600 ks observation of the original source **EXO 0748-676** (Cottam et al. 2008; Rauch et al. 2008)

High-resolution spectra (Cottam, Paerels, & Mendez 2002)



The **diversity of shapes** in XRB light curves (Galloway et al. 2007, Lewin et al. 1993, Kuulkers et al. 2003) is also likely due to **different nuclear histories** (Heger et al. 2007: interplay between long bursts and the extension of the rp-process in XRBs)

Strohmeyer & Bildsten (2002)
4U 1728 –34,
RXTE

Nucleosynthesis in Type I X-Ray Bursts

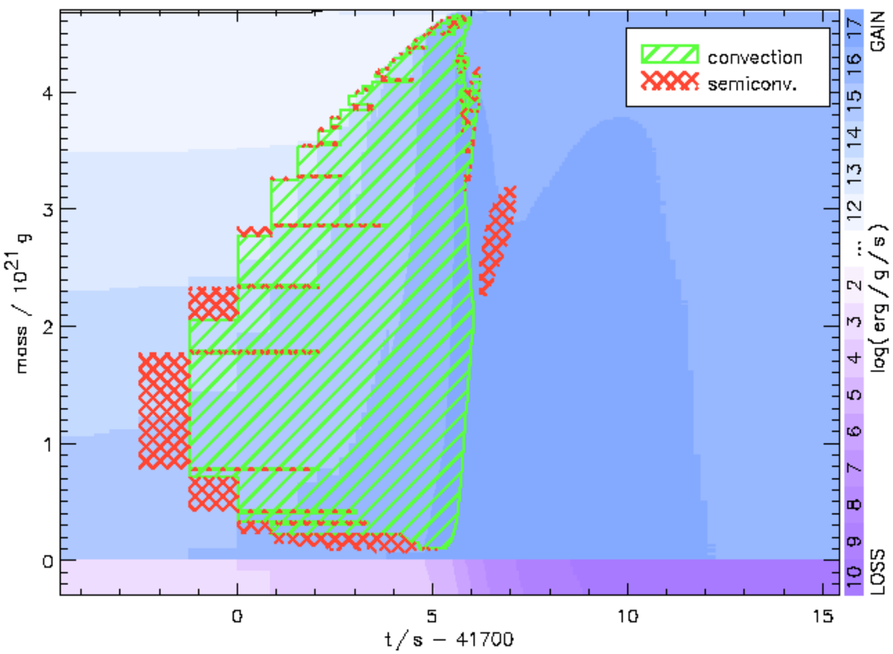
Santa Fe, NM

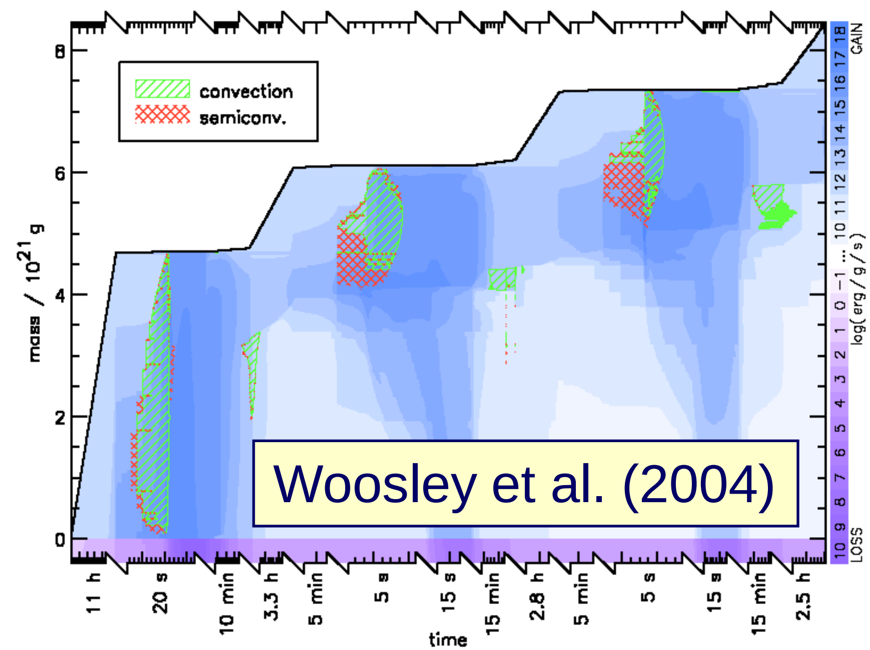
NS → $T_{peak} > 10^9$ **K,** $\rho_{max} \sim 10^6$ **g.cm**$^{-3}$

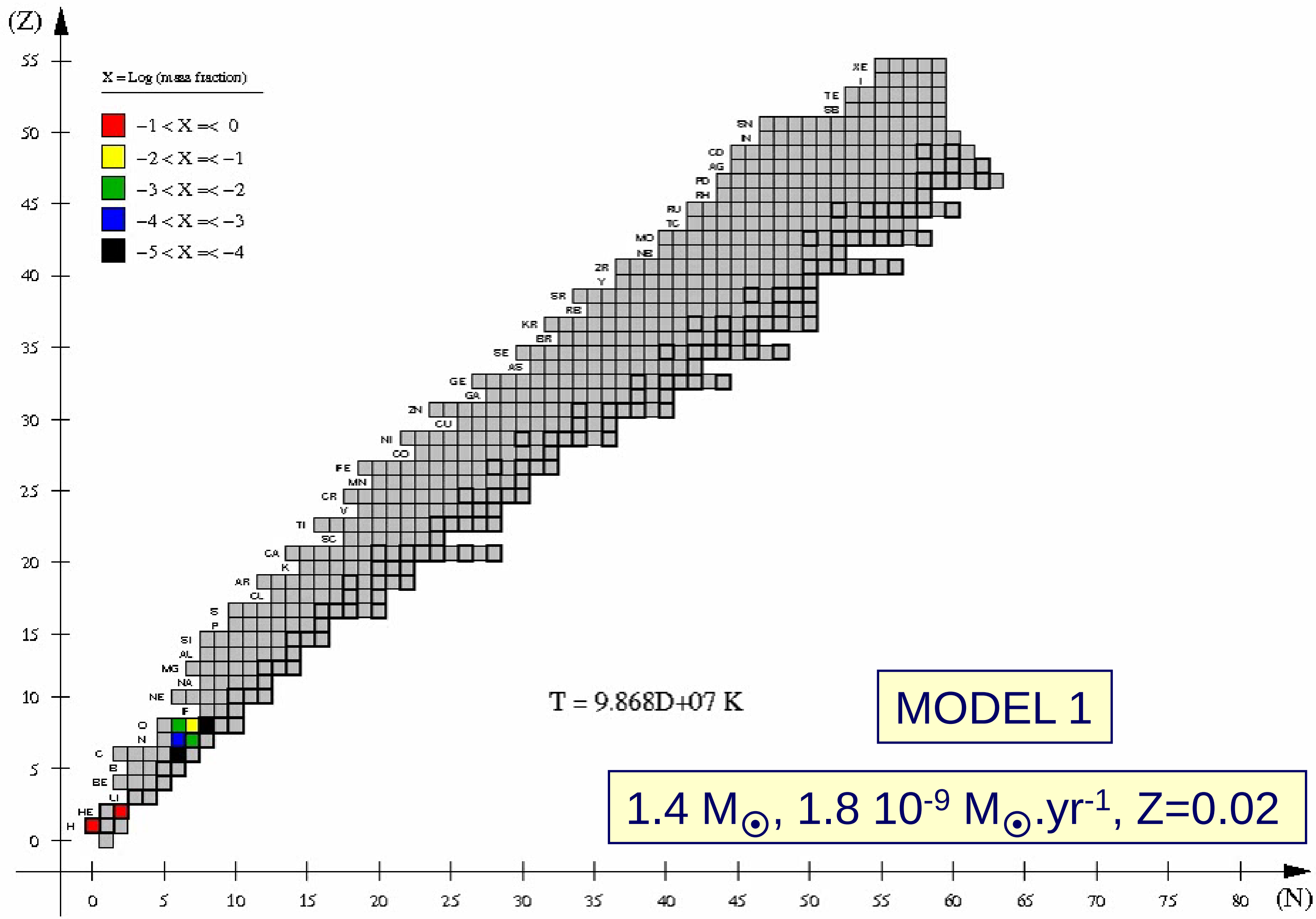
Detailed nucleosynthesis studies require **hundreds of isotopes**, up to **SnSbTe** mass region (Schatz et al. 2001) or beyond (the flow in Koike et al. 2004 reaches ^{126}Xe), and thousands of nuclear interactions

Main nuclear reaction flow driven by the *rp-process* (rapid p-captures and β^+-decays), the 3α-reaction, and the *αp-process* (a sequence of (α,p) and (p,γ) reactions), and proceeds away from the valley of stability, merging with the proton drip-line beyond **A = 38** (Schatz et al. 1999), and fuel consumption halts the TNR.

Recent attempts to couple **1-D hydrodynamic calculations** [No realistic multi-D simulation performed to date!] and **detailed networks** include Fisker et al. (2004, 2006, 2007, 2008) and Tan et al. (2007) (using networks of **~300 isotopes**, up to **^{107}Te**), JJ et al. (2010) (using a network of **1400 nuclear reactions**, and **325 isotopes**, up to **Te**) and Woosley et al. (2004), Heger et al. (2007) (using up to **1300 isotopes** with an adaptive network)







MODEL 1

1.4 $M_\odot$, 1.8 10^{-9} $M_\odot.yr^{-1}$, Z=0.02

Type I XRB: JJ, Moreno, Parikh & Iliadis (2010), ApJS

The Astrophysical Journal, 728:118 (18pp), 2011 February 20 doi:10.1088/0004-637X/728/2/118

MULTIDIMENSIONAL MODELING OF TYPE I X-RAY BURSTS. I. TWO-DIMENSIONAL CONVECTION PRIOR TO THE OUTBURST OF A PURE ^{4}He ACCRETOR

C. M. Malone[1], A. Nonaka[2], A. S. Almgren[2], J. B. Bell[2], and M. Zingale[1]
[1] Department of Physics & Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA; cmalone@mail.astro.sunysb.edu
[2] Center for Computational Sciences and Engineering, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
Received 2010 September 13; accepted 2010 December 14; published 2011 January 28

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 178:110–136, 2008 September

THE EFFECTS OF VARIATIONS IN NUCLEAR PROCESSES
ON TYPE I X-RAY BURST NUCLEOSYNTHESIS

ANUJ PARIKH[1]
Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, E-08036 Barcelona, Spain; xrayburst@gmail.com
JORDI JOSÉ
Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, E-08036 Barcelona; and Institut d'Estudis Espacials de Catalunya (IEEC), E-08034 Barcelona, Spain; jordi.jose@upc.edu
FERMÍN MORENO
Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, E-08036 Barcelona, Spain; moreno@ieec.fcr.es
AND
CHRISTIAN ILIADIS
Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255; and Triangle Universities Nuclear Laboratory, Durham, NC 27708-0308; iliadis@unc.edu
Received 2008 February 20; accepted 2008 April 30

~ **50,000** post-processing calculations [21 CPU months!]

606 isotopes (**^{1}H** to **^{113}Xe**) and **3551** nuclear processes

TABLE 19

Summary of the Most Influential Nuclear Processes, as Collected from Tables 1–10

Reaction	Models Affected
^{12}C(α, γ)^{16}O[a]	F08, K04-B2, K04-B4, K04-B5
^{18}Ne(α, p)^{21}Na[a]	K04-B1[b]
^{25}Si(α, p)^{28}P	K04-B5
^{26g}Al(α, p)^{29}Si	F08
^{29}S(α, p)^{32}Cl	K04-B5
^{30}P(α, p)^{33}S	K04-B4
^{30}S(α, p)^{33}Cl	K04-B4,[b] K04-B5[b]
^{31}Cl(p, γ)^{32}Ar	K04-B1
^{32}S(α, γ)^{36}Ar	K04-B2
^{56}Ni(α, p)^{59}Cu	S01,[b] K04-B5
^{57}Cu(p, γ)^{58}Zn	F08
^{59}Cu(p, γ)^{60}Zn	S01,[b] K04-B5
^{61}Ga(p, γ)^{62}Ge	F08, K04-B1, K04-B2, K04-B5, K04-B6
^{65}As(p, γ)^{66}Se	K04,[b] K04-B1, K04-B2,[b] K04-B3,[b] K04-B4, K04-B5, K04-B6
^{69}Br(p, γ)^{70}Kr	K04-B7
^{75}Rb(p, γ)^{76}Sr	K04-B2
^{82}Zr(p, γ)^{83}Nb	K04-B6
^{84}Zr(p, γ)^{85}Nb	K04-B2
^{84}Nb(p, γ)^{85}Mo	K04-B6
^{85}Mo(p, γ)^{86}Tc	F08
^{86}Mo(p, γ)^{87}Tc	F08, K04-B6
^{87}Mo(p, γ)^{88}Tc	K04-B6
^{92}Ru(p, γ)^{93}Rh	K04-B2, K04-B6
^{93}Rh(p, γ)^{94}Pd	K04-B2
^{96}Ag(p, γ)^{97}Cd	K04, K04-B2, K04-B3, K04-B7
^{102}In(p, γ)^{103}Sn	K04, K04-B3
^{103}In(p, γ)^{104}Sn	K04-B3, K04-B7
^{103}Sn(α, p)^{106}Sb	S01[b]

Notes.—These reactions affect the yields of at least three isotopes when their nominal rates are varied by a factor of 10 up and/or down. See text for details.

[a] Reaction experimentally constrained to better than a factor of ~10 at XRB temperatures. See § 5.

[b] Reaction that affects the total energy generation rate by more than 5% at some time interval in this model, when its rate is varied by a factor of 10 up and/or down. See text and Table 20 for details.

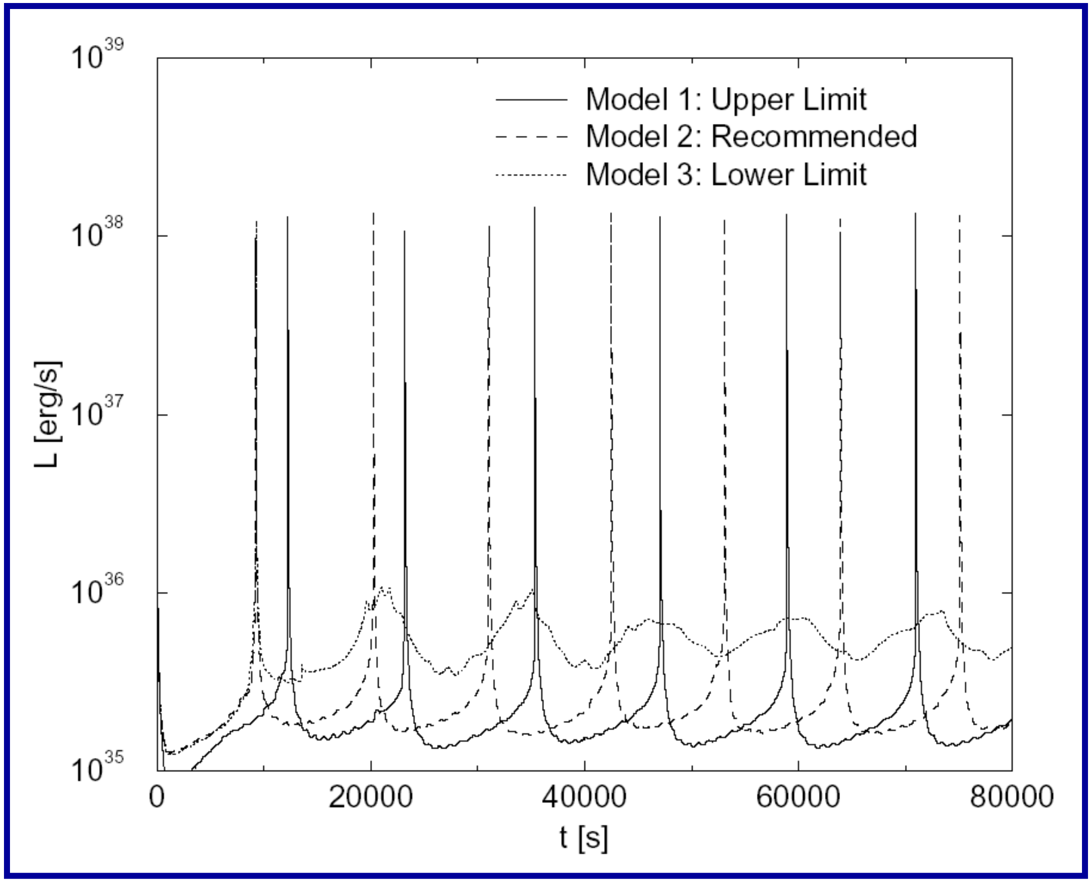
TABLE 20

Nuclear Processes Affecting the Total Energy Output by More than 5% and at Least One Isotope

Reaction	Models Affected
^{15}O(α, γ)^{19}Ne[a]	K04, K04-B1, K04-B6
^{18}Ne(α, p)^{21}Na[a]	K04-B1, K04-B6
^{22}Mg(α, p)^{25}Al	F08
^{23}Al(p, γ)^{24}Si	K04-B1
^{24}Mg(α, p)^{27}Al[a]	K04-B2
^{26g}Al(p, γ)^{27}Si[a]	F08
^{28}Si(α, p)^{31}P[a]	K04-B4
^{30}S(α, p)^{33}Cl	K04-B4, K04-B5
^{31}Cl(p, γ)^{32}Ar	K04-B3
^{32}S(α, p)^{35}Cl	K04-B2
^{35}Cl(p, γ)^{36}Ar[a]	K04-B2
^{56}Ni(α, p)^{59}Cu	S01
^{59}Cu(p, γ)^{60}Zn	S01
^{65}As(p, γ)^{66}Se	K04, K04-B2, K04-B3
^{69}Br(p, γ)^{70}Kr	S01
^{71}Br(p, γ)^{72}Kr	K04-B7
^{103}Sn(α, p)^{106}Sb	S01

Few attempts to analyze the impact of a single nuclear reaction rate (& uncertainty) into the overall nucleosynthesis

* **$^{21}Na(p,\gamma)^{22}Mg$:** D'Auria et al (2004)



Role of $^{15}O(\alpha,\gamma)^{19}Ne$ on type I XRB light curves (Fisker et al. 2006). But see Davids, Cyburt, JJ & Mythili (2011) €€

PHYSICAL REVIEW C **84**, 045807 (2011)

Mass measurements of isotopes of Nb, Mo, Tc, Ru, and Rh along the νp- and rp-process paths using the Canadian Penning trap mass spectrometer

J. Fallis,[1,2,*] J. A. Clark,[2,3,1] K. S. Sharma,[1] G. Savard,[2,4] F. Buchinger,[5] S. Caldwell,[4,2] A. Chaudhuri,[1,2] J. E. Crawford,[5] C. M. Deibel,[3,6] S. Gulick,[5] A. A. Hecht,[7,2] D. Lascar,[8,2] J. K. P. Lee,[5] A. F. Levand,[2] G. Li,[5,2] B. F. Lundgren,[2] A. Parikh,[9] S. Russell,[1,2] M. Scholte-van de Vorst,[1,2] N. D. Scielzo,[2,10] R. E. Segel,[8] H. Sharma,[1,2] S. Sinha,[2] M. G. Sternberg,[4,2] T. Sun,[2] I. Tanihata,[2] J. Van Schelt,[4,2] J. C. Wang,[1,2] Y. Wang,[1,2] C. Wrede,[3] and Z. Zhou[2]

[1]*Department of Physics, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada*
[2]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[3]*Wright Nuclear Structure Laboratory, Yale University, New Haven, Connecticut 06520, USA*
[4]*Department of Physics, University of Chicago, Chicago, Illinois 60637, USA*
[5]*Department of Physics, McGill University, Montréal, Québec H3A 2T8, Canada*
[6]*Joint Institute for Nuclear Astrophysics, Michigan State University, East Lansing, Michigan 48824, USA*
[7]*Department of Chemistry and Biochemistry, University of Maryland, College Park, Maryland 20742, USA*
[8]*Department of Physics and Astronomy, Northwestern University, Evanston, Illinois 60208, USA*
[9]*Physik Department E12, Technische Universität München, D-85748 Garching, Germany*
[10]*Physical Sciences Directorate, Lawrence Livermore National Laboratory, Livermore, California 94550, USA*

(Received 19 May 2011; published 19 October 2011)

ARTICLE

doi:10.1038/nature11116

Superallowed Gamow–Teller decay of the doubly magic nucleus ^{100}Sn

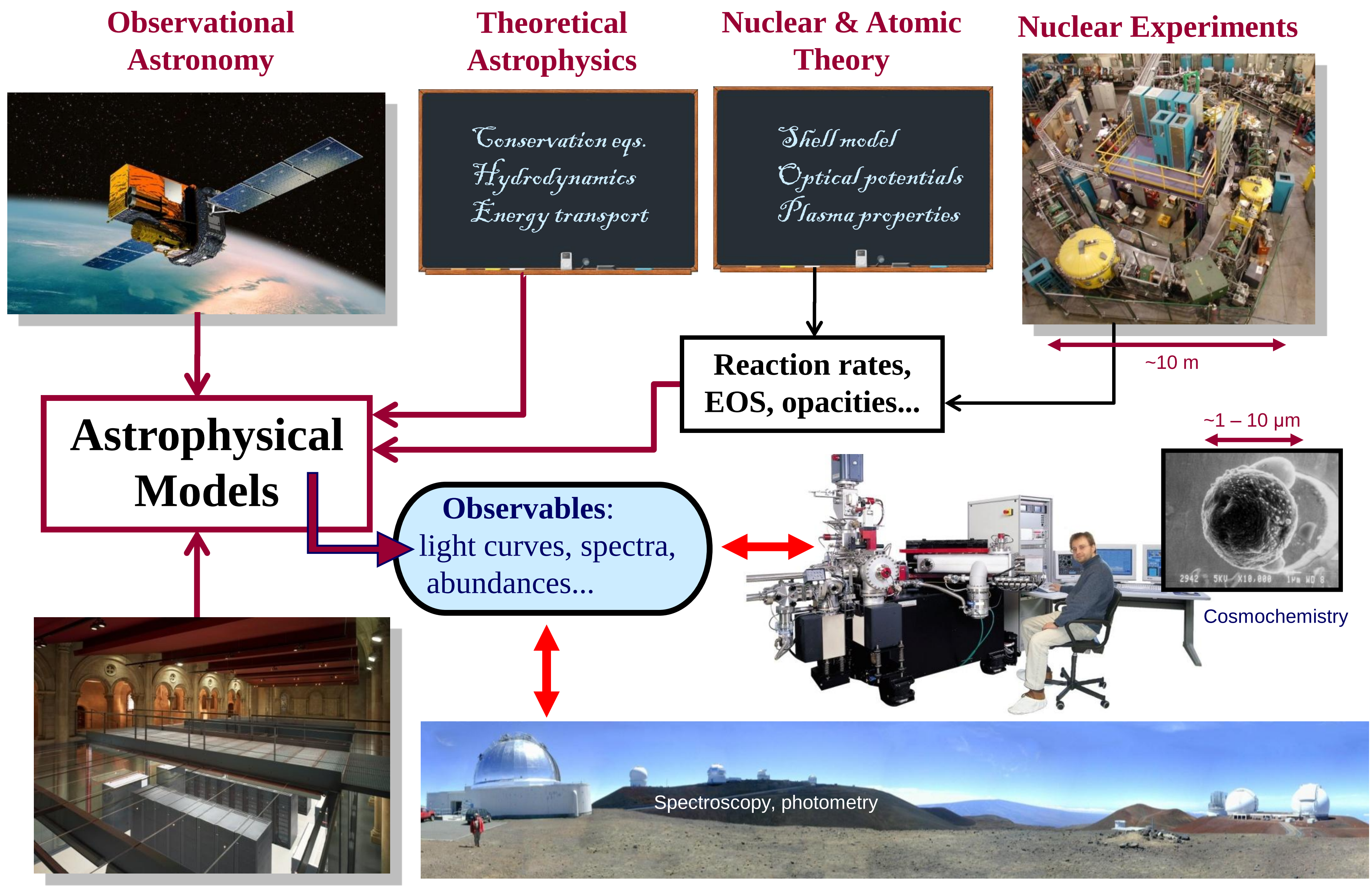
C. B. Hinke[1], M. Böhmer[1], P. Boutachkov[2], T. Faestermann[1], H. Geissel[2], J. Gerl[2], R. Gernhäuser[1], M. Górska[2], A. Gottardo[3], H. Grawe[2], J. L. Grębosz[4], R. Krücken[1,5], N. Kurz[2], Z. Liu[6], L. Maier[1], F. Nowacki[7], S. Pietri[2], Zs. Podolyák[8], K. Sieja[7], K. Steiger[1], K. Straub[1], H. Weick[2], H.-J. Wollersheim[2], P. J. Woods[6], N. Al-Dahan[8], N. Alkhomashi[8], A. Ataç[9], A. Blazhev[10], N. F. Braun[10], I. T. Čeliković[11], T. Davinson[6], I. Dillmann[2], C. Domingo-Pardo[12], P. C. Doornenbal[13], G. de France[14], G. F. Farrelly[8], F. Farinon[2], N. Goel[2], T. C. Habermann[2], R. Hoischen[2], R. Janik[15], M. Karny[16], A. Kaşkaş[9], I. M. Kojouharov[2], Th. Kröll[17], Y. Litvinov[2], S. Myalski[4], F. Nebel[1], S. Nishimura[13], C. Nociforo[2], J. Nyberg[18], A. R. Parikh[19], A. Procházka[2], P. H. Regan[8], C. Rigollet[20], H. Schaffner[2], C. Scheidenberger[2], S. Schwertel[1], P.-A. Söderström[13], S. J. Steer[8], A. Stolz[21] & P. Strmeň[15]

The Astrophysical Journal Supplement Series, 189:240–252, 2010 July
doi:10.1088/0067-0049/189/1/240

THE JINA REACLIB DATABASE: ITS RECENT UPDATES AND IMPACT ON TYPE-I X-RAY BURSTS

Richard H. Cyburt[1,2,9], A. Matthew Amthor[1,2,3], Ryan Ferguson[1,2,3], Zach Meisel[1,2,3], Karl Smith[1,2,3], Scott Warren[1,2,4], Alexander Heger[1,5], R. D. Hoffman[6], Thomas Rauscher[7], Alexander Sakharuk[1,2], Hendrik Schatz[1,2,3], F. K. Thielemann[7], and Michael Wiescher[1,8]
[1] Joint Institute for Nuclear Astrophysics (JINA), http://www.jinaweb.org
[2] National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA
[3] Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA
[4] Department of Electrical and Computer Engineering, Michigan State University, East Lansing, MI 48824, USA
[5] School of Physics & Astronomy, University of Minnesota, Twin Cities, Minneapolis, MN 55455, USA
[6] Lawrence Livermore National Laboratory, P.O. Box 808, L-414 Livermore, CA 94550, USA
[7] Department of Physics, University of Basel, 4056 Basel, Switzerland
[8] Department of Physics, University of Notre Dame, Notre Dame, IN 46556, USA
Received 2009 November 23; accepted 2010 May 12; published 2010 June 30

€€


Observational Astronomy
Theoretical Astrophysics
Nuclear & Atomic Theory
Nuclear Experiments
Conservation eqs.
Hydrodynamics
Energy transport
Shell model
Optical potentials
Plasma properties
~10 m
Reaction rates, EOS, opacities...
Astrophysical Models
~1 – 10 μm
Observables: light curves, spectra, abundances...
Cosmochemistry
Spectroscopy, photometry

Thank you for your attention!

Stellar Beacons:
Classical Novae, Type Ia Supernovae, Type I X-Ray Bursts,
& Stellar Mergers

The Origin of Cosmic Elements, Barcelona, June 12-15, 2013