Neutrinos in the Big Bang and Supernovae

G. J. Mathews – University of Notre Dame

Interactions with George – Deviations in the big bang

Interactions with Baha – Deviations in spectra

Neutrinos in Physics and Astrophysics:
Celebrating the contributions of Baha Balantekin and George Fuller
Jan 16-18 2025
UC Berkeley
131 Campbell Hall

The Caltech Years

Ca. 1978-1981

The Caltech Years

Ca. 1996

Deviations in the Neutrino Distribution during BBN

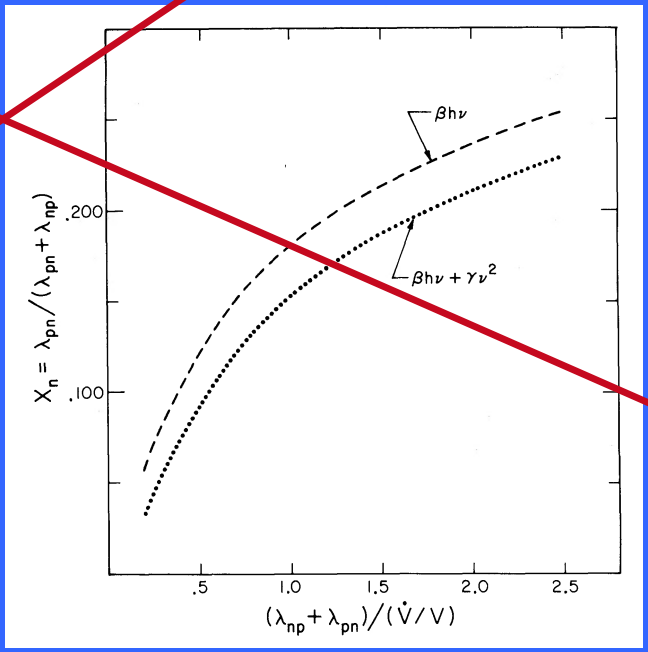
MAF

THE ASTROPHYSICAL JOURNAL, 246:361–364, 1981 June 1

DISTORTIONS IN THE COSMIC BACKGROUND RADIATION AND BIG-BANG ^{4}He NUCLEOSYNTHESIS[1]

G. J. MATHEWS, Y. ALHASSID,[2] AND G. M. FULLER[3]
W. K. Kellogg Radiation Laboratory, California Institute of Technology
Received 1980 October 2; accepted 1980 December 8

$$dn_i(\epsilon) = \frac{4\pi}{h^3} g_i \frac{{p_i}^2 dp_i}{\exp\left(\beta\epsilon_i + \gamma{\epsilon_i}^2\right) + 1}$$



The Livermore Years

Deviations in BBN

THE ASTROPHYSICAL JOURNAL, 320:439–447, 1987 September 15

THE QUARK-HADRON PHASE TRANSITION AND PRIMORDIAL NUCLEOSYNTHESIS

C. ALCOCK, G. M. FULLER, AND G. J. MATHEWS
Institute of Geophysics and Planetary Physics, University of California, and Lawrence Livermore National Laboratory
Received 1987 January 20; accepted 1987 March 13

PHYSICAL REVIEW D VOLUME 37, NUMBER 6 15 MARCH 1988

Quark-hadron phase transition in the early Universe: Isothermal baryon-number fluctuations and primordial nucleosynthesis

G. M. Fuller, G. J. Mathews, and C. R. Alcock
Institute of Geophysics and Planetary Physics, University of California, Lawrence Livermore National Laboratory, Livermore, California 94550
(Received 11 September 1987)

THE ASTROPHYSICAL JOURNAL, 358:36–46, 1990 July 20

COUPLED BARYON DIFFUSION AND NUCLEOSYNTHESIS IN THE EARLY UNIVERSE

G. J. MATHEWS, B. S. MEYER, AND C. R. ALCOCK
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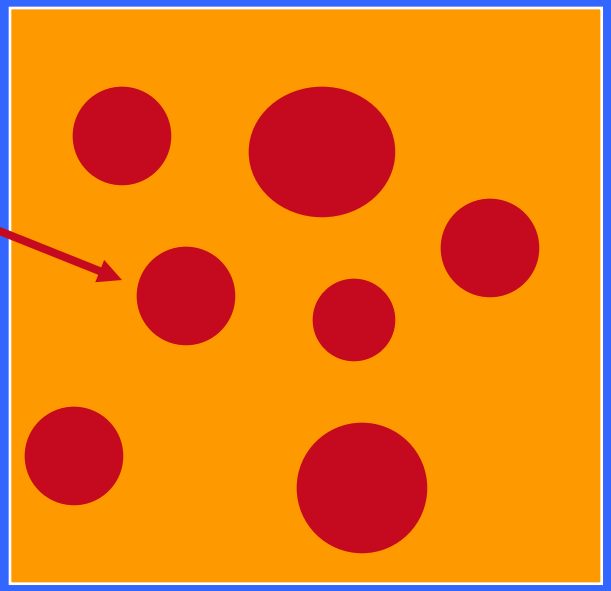
AND
G. M. FULLER
Physics Department, University of California, San Diego
Received 1989 November 17; accepted 1990 January 24

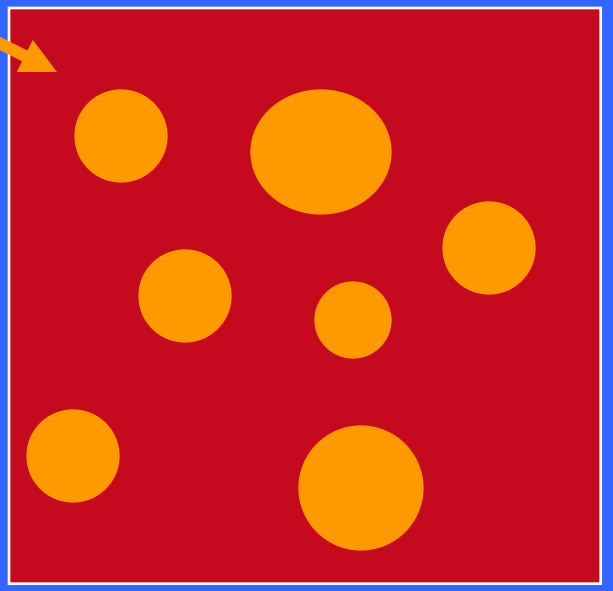
Big Bang Nucleosynthesis and the Cosmic Quark-Hadron Phase Transiton

Quark-Gluon Plasma

This could lead to inhomogeneities during BBN

Hadron Phase
p,n,π, ..





Evolution of the volume fraction

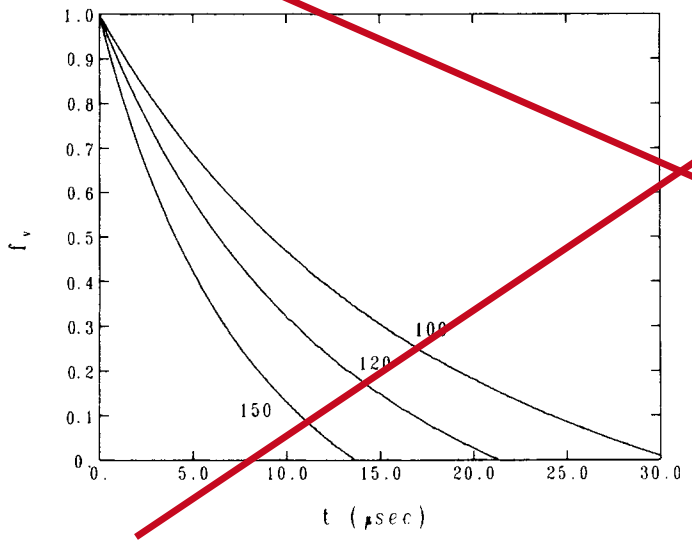


FIG. 4. The quark-gluon plasma volume fraction f_v as a function of the time since the end of the nucleation epoch. Curves for three different values of coexistence temperature, $T_c = 100$, 150, and 200 MeV are shown.

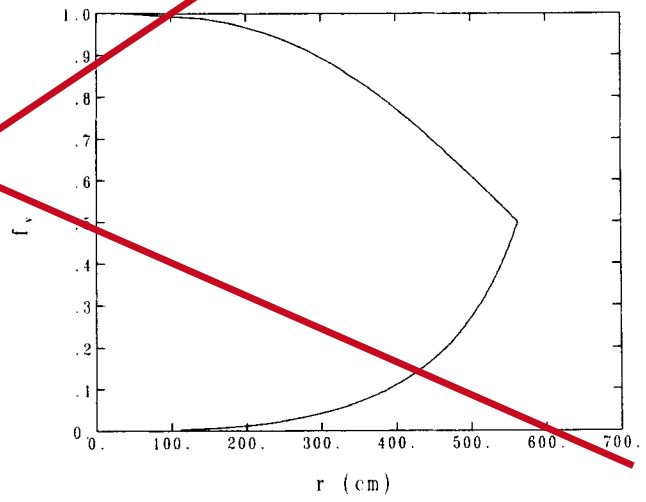
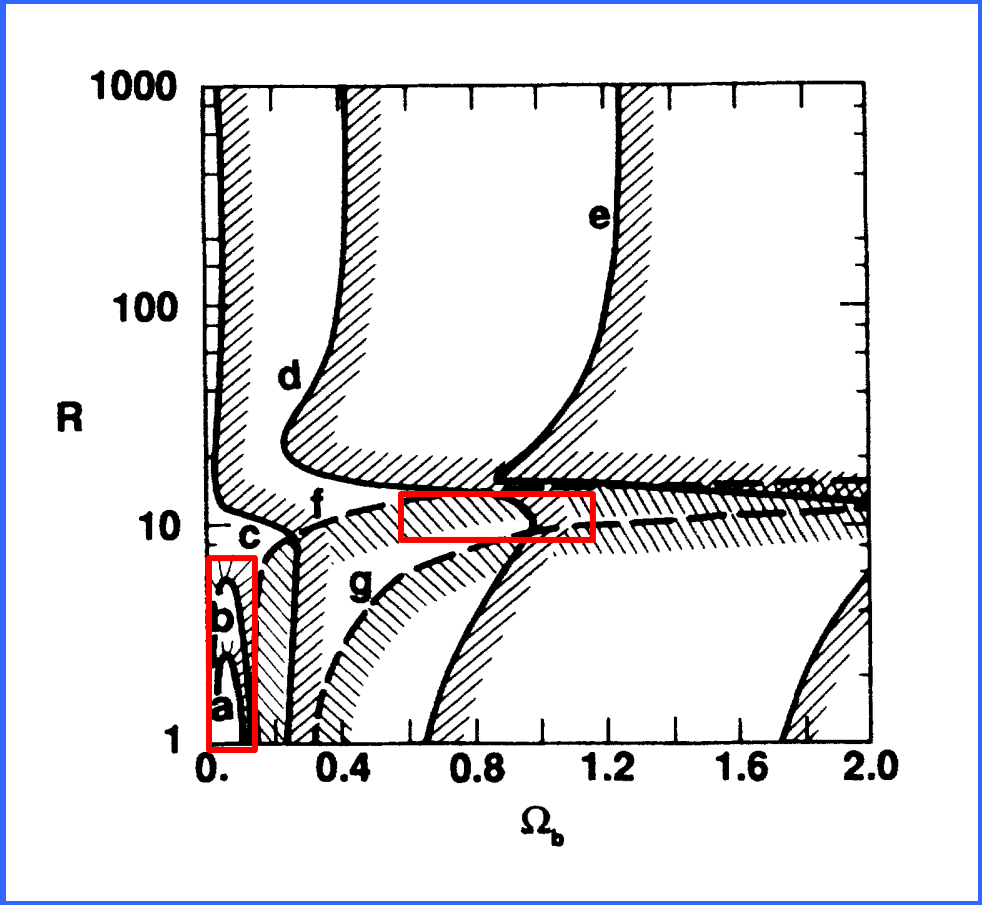


FIG. 5. The quark-gluon plasma volume fraction f_v is plotted against proper bubble radius r. The parameter is interpreted as the radius of a growing bubble of hadron phase for $f_v > 0.5$ and the radius of a shrinking bubble of quark-gluon plasma for $f_v \leq 0.5$.

Evidence of the cosmic QCD transition in BBN?

Density Ratio



Too much ^{7}Li

THE ASTROPHYSICAL JOURNAL, **349**:449–457, 1990 February 1

GALACTIC CHEMICAL EVOLUTION WITH LOW AND HIGH PRIMORDIAL LITHIUM

G. J. MATHEWS AND C. R. ALCOCK
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AND

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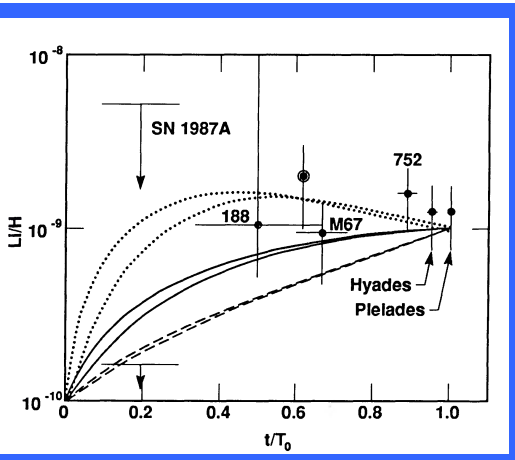
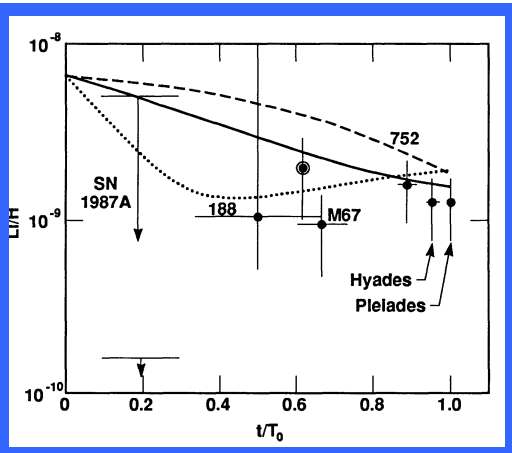
Physics Department, University of California at San Diego
Received 1989 February 8; accepted 1989 July 21





THE ASTROPHYSICAL JOURNAL, 403:65–73, 1993 January 20

CHEMICAL EVOLUTION OF IRREGULAR GALAXIES AND THE PRIMORDIAL ^{4}He ABUNDANCE

G. J. MATHEWS
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AND

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Received 1992 January 24; accepted 1992 July 28

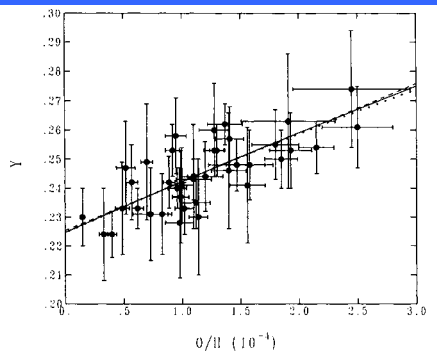


FIG. 1.—*Y* vs. O/H data of Pagel (1991) compared to the best straight-line fit (*dashed line*), the hierarchical clustering, closed box, or accretion models (*solid line*), and the best numerical fit (*dotted line*) for the hierarchical clustering model with the instantaneous recycling approximation relaxed and with an assumed exponential star formation rate.

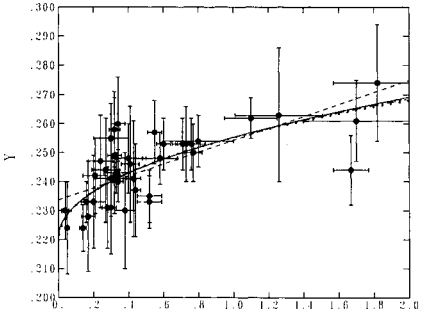


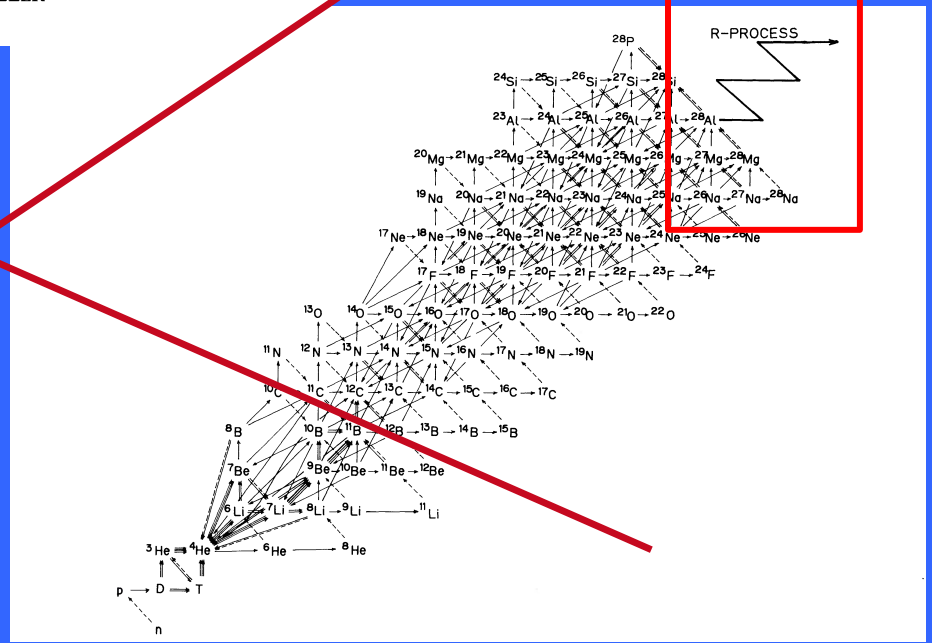
FIG. 2.—*Y* vs. N/H data of Pagel (1991) compared to the best straight-line fit (*dashed line*), the hierarchical clustering or closed-box model (*solid line*), the accretion model (*dot-dashed line*), and the numerical model with the instantaneous recycling approximation relaxed (*dotted line*).

THE ASTROPHYSICAL JOURNAL, 364:7–14, 1990 November 20

PRIMORDIAL NUCLEOSYNTHESIS OF INTERMEDIATE-MASS ELEMENTS IN BARYON-NUMBER–INHOMOGENEOUS BIG BANG MODELS: OBSERVATIONAL TESTS

T. KAJINO,[1] G. J. MATHEWS,[2] AND G. M. FULLER[3]

Received 1990 January 19; accepted 1990 May 17



VOLUME 64, NUMBER 22 PHYSICAL REVIEW LETTERS 28 MAY 1990

Late-Time Dissipation of Primordial Baryon-Number Fluctuations and Nucleosynthesis

C. R. Alcock,[(1)] D. S. Dearborn,[(1)] G. M. Fuller,[(1,2)] G. J. Mathews,[(1)] and B. S. Meyer[(1)]

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(Received 17 October 1989)

PHYSICAL REVIEW D VOLUME 43, NUMBER 4 15 FEBRUARY 1991

Spectrum of QCD nucleation-site separations and primordial nucleosynthesis

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Institute of Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, Livermore, California 94550

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(Received 21 June 1990)

THE ASTROPHYSICAL JOURNAL, 422:423–429, 1994 February 20

ENHANCED HEAVY-ELEMENT FORMATION IN BARYON-INHOMOGENEOUS BIG BANG MODELS

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AND
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Received 1993 May 14; accepted 1993 August 23

THE ASTROPHYSICAL JOURNAL, 423:50–67, 1994 March 1

INHOMOGENEOUS PRIMORDIAL NUCLEOSYNTHESIS: COUPLED NUCLEAR REACTIONS AND HYDRODYNAMIC DISSIPATION PROCESSES

KARSTEN JEDAMZIK[1] AND GEORGE M. FULLER
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AND
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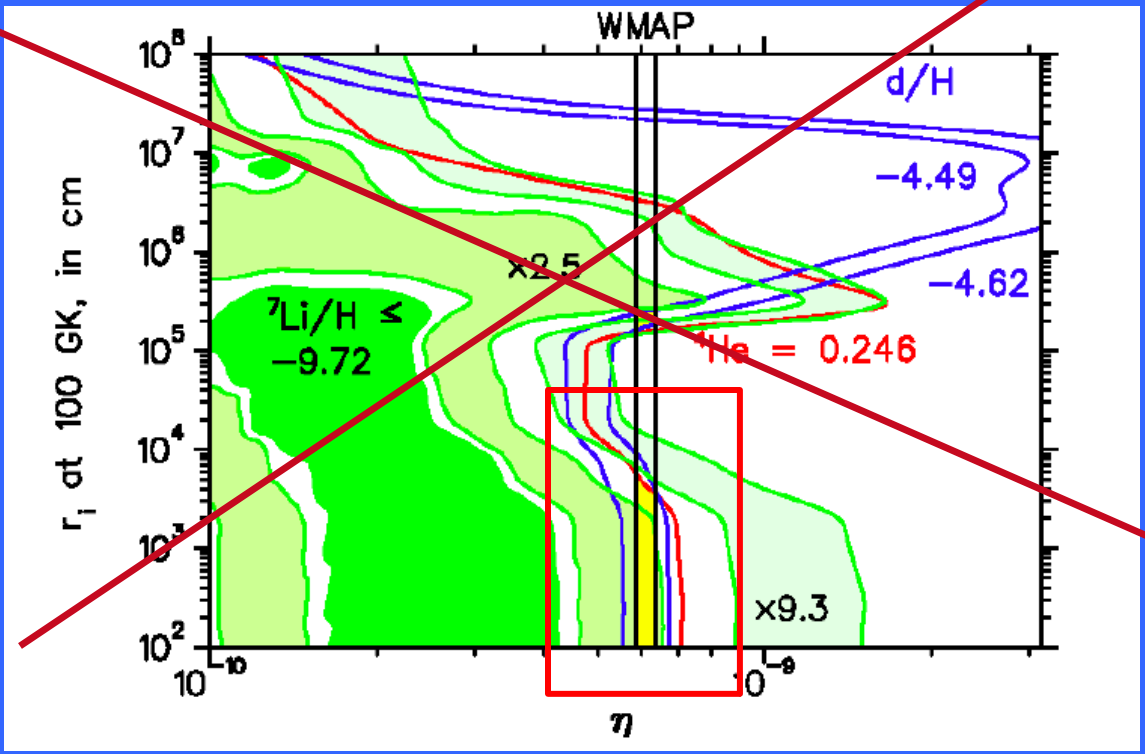
Received 1993 June 21; accepted 1993 August 30

Evidence of the cosmic QCD transition in BBN?



Lara, Kajino, Mathews, PRD (2006)

Maybe there is another way to make an inhomogeneous big bang

ELSEVIER

28 July 1994

PHYSICS LETTERS B

Physics Letters B 333 (1994) 135–141

On constraining electroweak-baryogenesis with inhomogeneous primordial nucleosynthesis

G.M. Fuller [a], K. Jedamzik [a], G.J. Mathews [b], A. Olinto [c]

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Received 7 September 1993; revised manuscript received 25 April 1994

Editor: M. Dine

THE ASTROPHYSICAL JOURNAL, 441:465–470, 1995 March 10

ABSENCE OF A LOWER LIMIT ON Ω_b IN INHOMOGENEOUS PRIMORDIAL NUCLEOSYNTHESIS

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Physics Research Program, Institute for Geophysics and Planetary Physics, University of California, Lawrence Livermore National Laboratory, Livermore, CA 94550

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Department of Physics, University of California, San Diego, La Jolla, CA 92093-0319

Received 1994 June 10; accepted 1994 September 9

QCD and Neutrinos in Supernovae

THE ASTROPHYSICAL JOURNAL, 414:701–711, 1993 September 10

THE QCD PHASE TRANSITION AND SUPERNOVA CORE COLLAPSE

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F. D. SWESTY
Department of Physics and Department of Earth and Space Sciences,
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G. M. FULLER
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Received 1993 January 21; accepted 1993 March 12

VOLUME 71, NUMBER 13 PHYSICAL REVIEW LETTERS 27 SEPTEMBER 1993

Connection between Flavor Mixing of Cosmologically Significant Neutrinos and Heavy Element Nucleosynthesis in Supernovae

Yong-Zhong Qian and George M. Fuller
Department of Physics, University of California, San Diego, La Jolla, California 92093-0319
Grant J. Mathews, Ron W. Mayle, and James R. Wilson
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S. E. Woosley
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(Received 23 December 1992; revised manuscript received 21 June 1993)

Deviations in Large Scale Structure and Dark Energy

THE ASTROPHYSICAL JOURNAL, 356: L5–L7, 1990 June 10

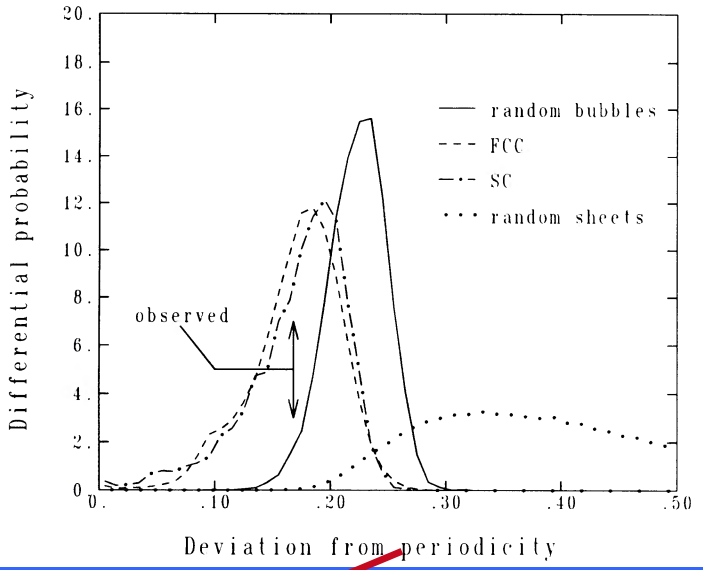
DEVIATION FROM PERIODICITY IN THE LARGE-SCALE DISTRIBUTION OF GALAXIES

H. KURKI-SUONIO AND G. J. MATHEWS
University of California, Lawrence Livermore National Laboratory
AND
G. M. FULLER
Physics Department, University of California, San Diego
Received 1990 January 23; accepted 1990 March 22

ABSTRACT

We investigate the recently observed periodicity of the distribution of galaxies at high redshift by comparing the data with models in which galaxies reside on the surfaces of bubbles or sheets. A statistical analysis of the deviation from periodicity along various lines of sight seems to suggest that the data more closely resemble a regular cellular pattern in which the bubble centers are strongly anticorrelated than a distribution produced by random voids or sheets. We discuss how such a regular structure might arise and suggest some observational tests of this interpretation.

Subject headings: cosmology — galaxies: redshifts — galaxies: structure



PHYSICAL REVIEW D **75,** 043521 (2007)

Bulk viscosity, decaying dark matter, and the cosmic acceleration

James R. Wilson
Lawrence Livermore National Laboratory, Livermore, California 94550, USA
Grant J. Mathews
Center for Astrophysics, Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, USA
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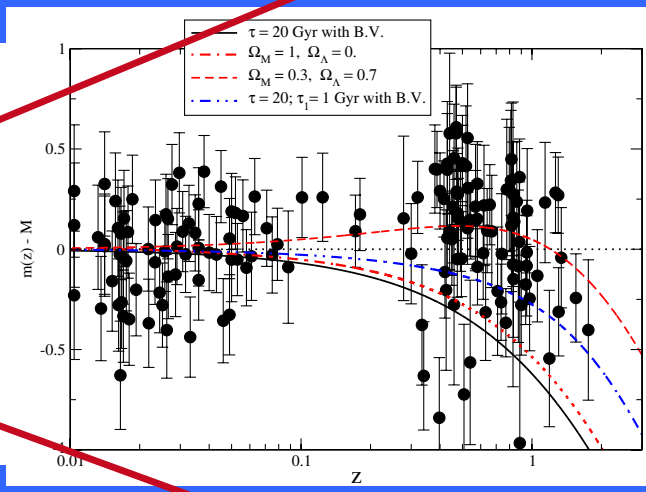
Department of Physics, University of California, San Diego, La Jolla, California 92093-0319, USA
(Received 25 September 2006; published 26 February 2007)



The NAOJ Years

Ca. 2010-2022

Deviations in the Photon Distribution for Photodisintegration

The Astrophysical Journal, 727:10 (12pp), 2011 January 20 doi:10.1088/0004-637X/727/1/10

QUANTUM STATISTICAL CORRECTIONS TO ASTROPHYSICAL PHOTODISINTEGRATION RATES

G. J. Mathews[1,3], Yamac Pehlivan[2,3], Toshitaka Kajino[3,4], A. B. Balantekin[5], and Motohiko Kusakabe[6]
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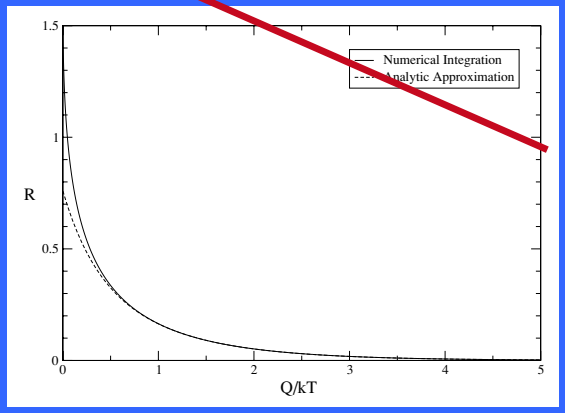
Received 2010 March 16; accepted 2010 October 27; published 2010 December 23

$$\langle \sigma c \rangle_{\gamma 3} = \frac{\mu c^3}{2\zeta(3)(kT)^3} \frac{g_1 g_2}{g_3(1+\delta_{12})} \times \int_0^\infty \sigma_{12}(E) \frac{1}{e^{(E+Q)/kT} - 1} E dE.$$

$$\langle \sigma c \rangle_{\gamma 3} = (1+R) \langle \sigma v \rangle_{12} \left(\frac{\sqrt{2\pi}}{8\zeta(3)} \right) \frac{g_1 g_2}{g_3(1+\delta_{12})} \left(\frac{\mu c^2}{kT} \right)^{3/2} e^{-Q/kT},$$



Deviation of Neutrino Spectra from Magnetars

Physics Letters B 779 (2018) 160–165

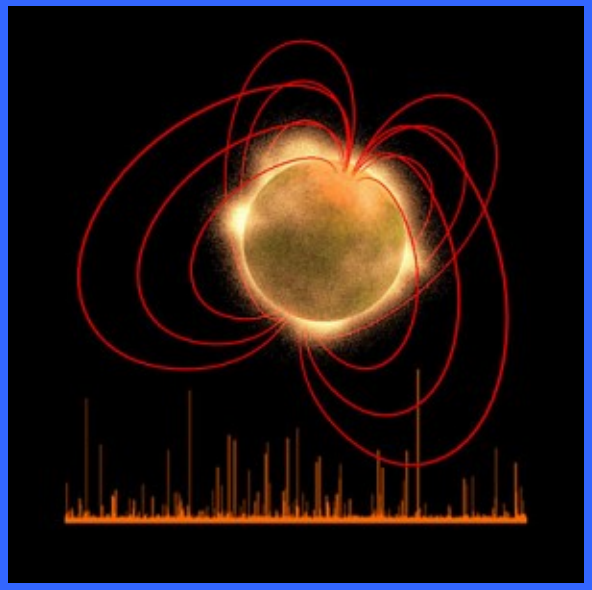
Contents lists available at ScienceDirect

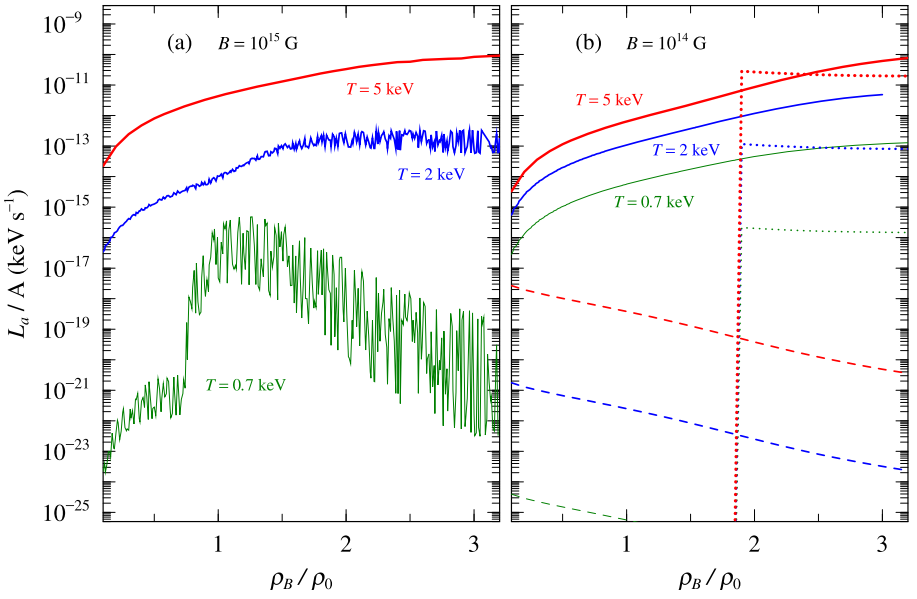
Physics Letters B

www.elsevier.com/locate/physletb

Axion production from Landau quantization in the strong magnetic field of magnetars

Tomoyuki Maruyama [a,b,*], A. Baha Balantekin [c,b], Myung-Ki Cheoun [f,b], Toshitaka Kajino [e,b,d], Grant J. Mathews [g,b]





Deviations in Neutrino Spectra in Synchrotron Emission

Physics Letters B 805 (2020) 135413

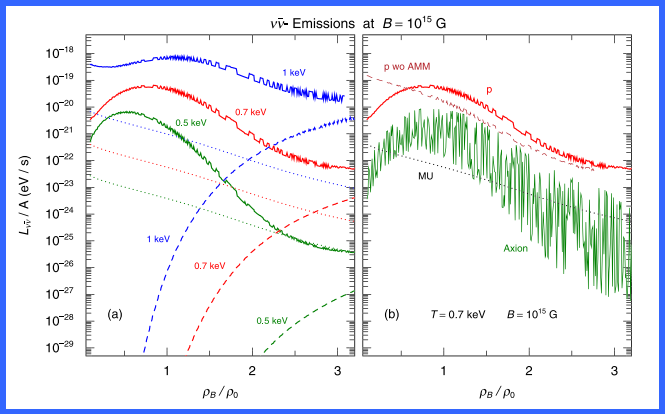
Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

$\nu\bar{\nu}$-Pair synchrotron emission in neutron-star matter based on a relativistic quantum approach

Tomoyuki Maruyama [a,b,*], A. Baha Balantekin [c,b], Myung-Ki Cheoun [f,b], Toshitaka Kajino [e,b,d], Grant J. Mathews [g,b]



Deviations in Neutrino Spectra in the Direct Urca Process

Physics Letters B 824 (2022) 136813

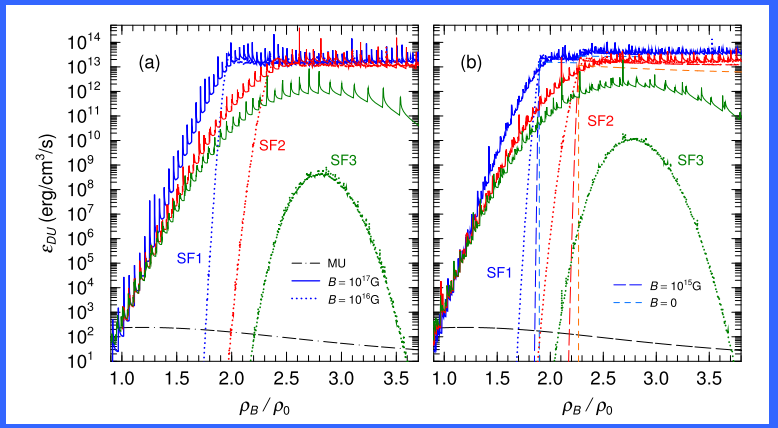
Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

A relativistic quantum approach to neutrino and antineutrino emission via the direct Urca process in strongly magnetized neutron-star matter

Tomoyuki Maruyama [a,b,c,*], A. Baha Balantekin [d,b], Myung-Ki Cheoun [e,b], Toshitaka Kajino [b,g,f], Motohiko Kusakabe [f,b], Grant J. Mathews [h,b]

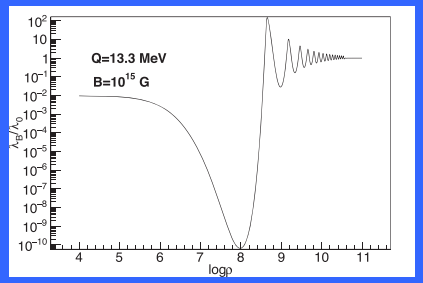


Deviations in Beta Decay Spectra in the Modified Urca Process

The Astrophysical Journal, 940:108 (12pp), 2022 December 1
https://doi.org/10.3847/1538-4357/ac9bf3

Evolution of Urca Pairs in the Crusts of Highly Magnetized Neutron Stars

Michael A. Famiano[1,2,3], Grant Mathews[3,4], A. Baha Balantekin[2,5], Toshitaka Kajino[6,2,7], Motohiko Kusakabe[6], and Kanji Mori[8]



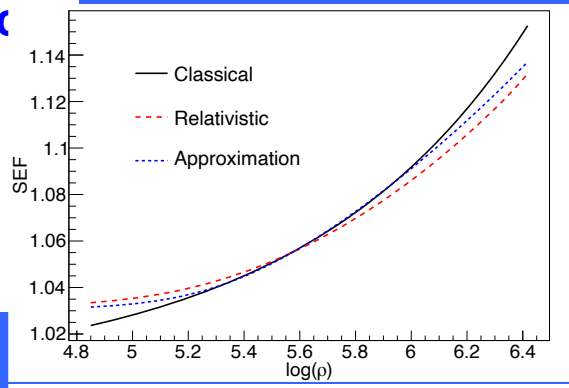
Deviations in Coulomb Screening Potentials

A&A 659, A97 (2022)
https://doi.org/10.1051/0004-6361/202142433

Astronomy & Astrophysic

Relativistic Coulomb screening in pulsational pair instability supernovae

M. A. Famiano[1,2,3], K. Mori[4], A. B. Balantekin[2,5], T. Kajino[2,6,7], M. Kusakabe[7], and G. Mathews[3,8]



Thanks George and Baha for many years of fun collaborations!!

- Keep up the search for deviations