What goes around comes around

What goes around comes around

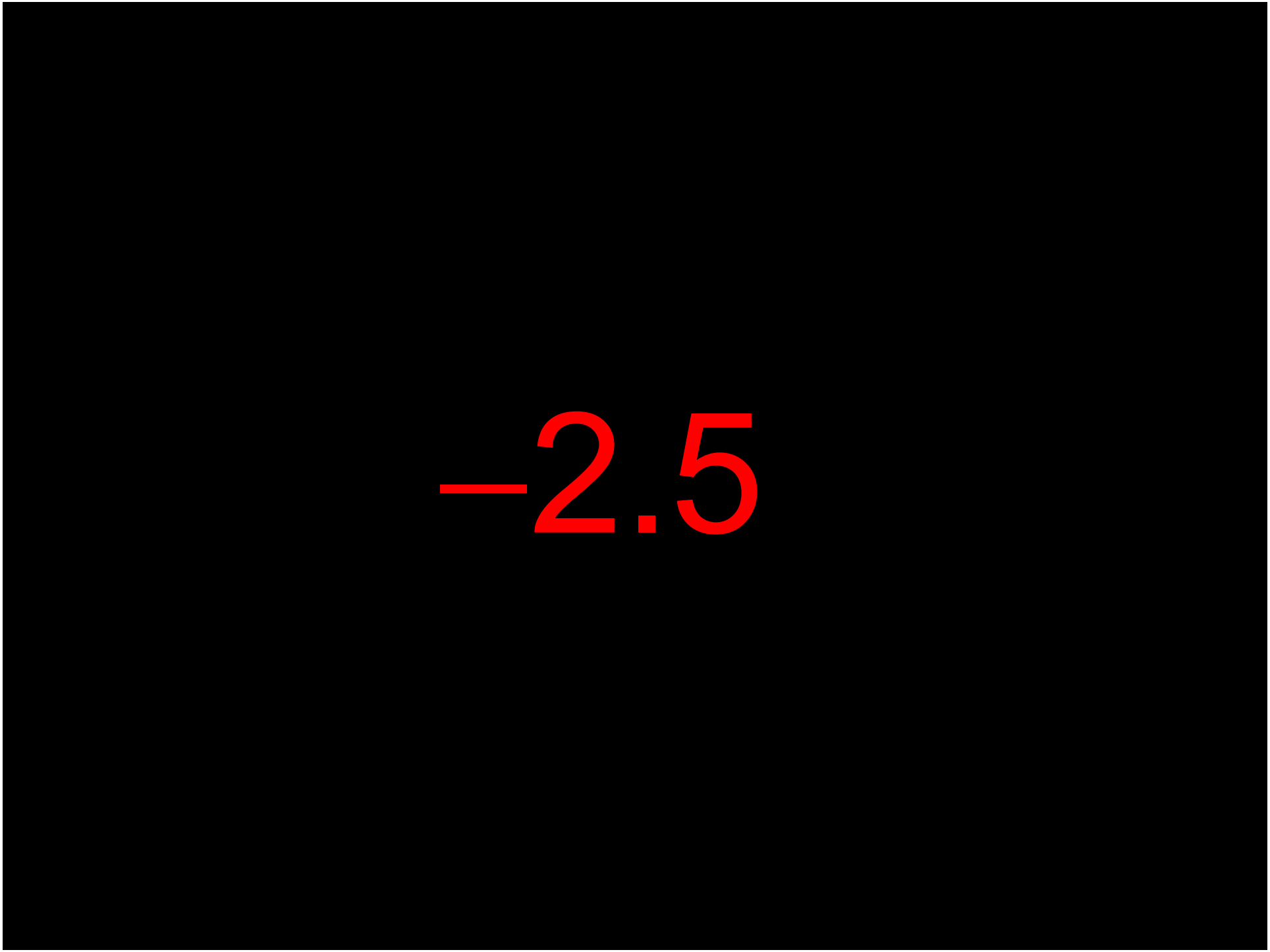
Bulges of Galaxies: A Celebration of the 90th Birthday of Albert Whitford

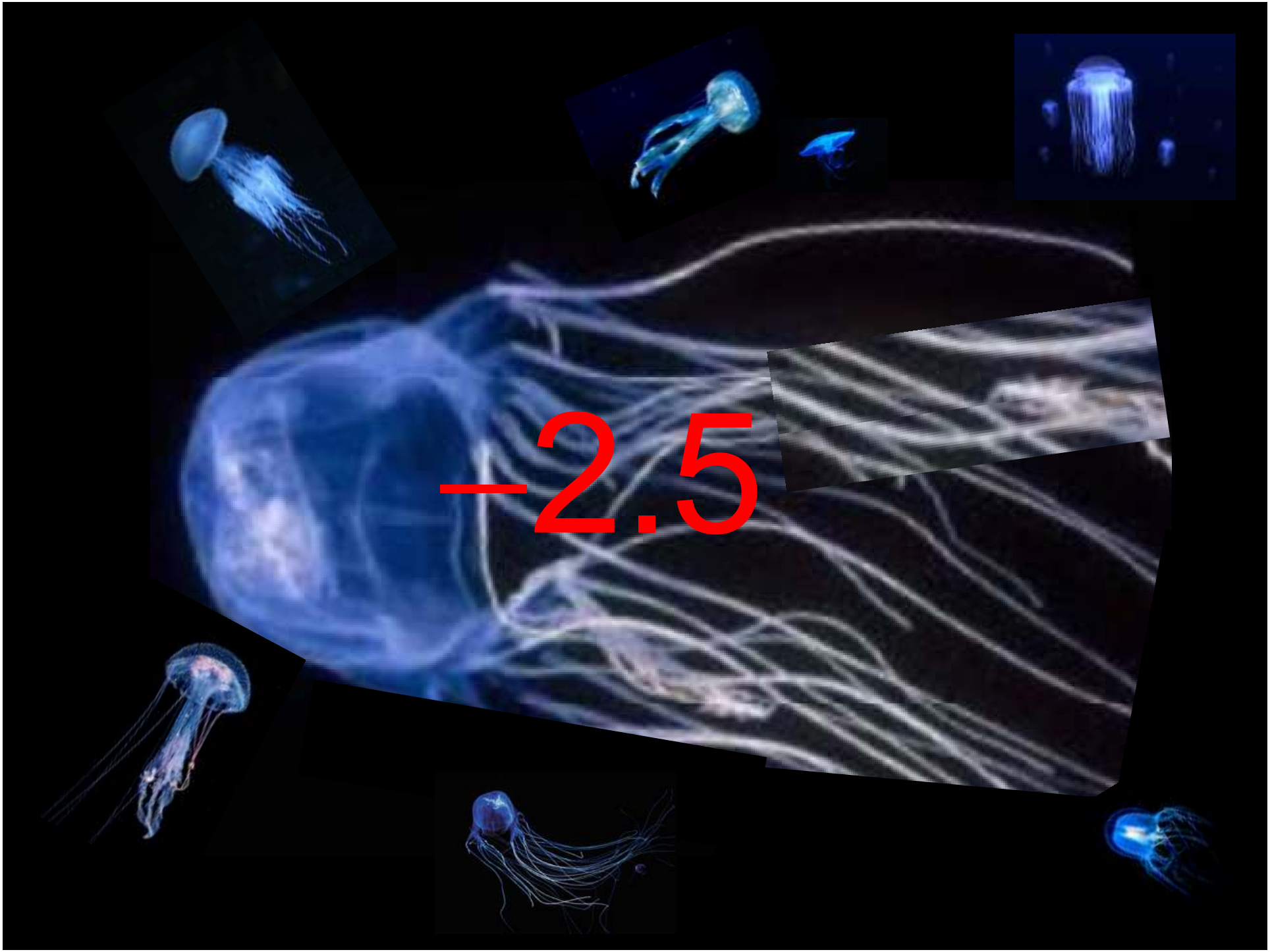
Rich & Terndrup 1997, PASP, 109, 571

On the weekend of March 23–25, 1996, several dozen astronomers gathered under the redwoods at the University of California, Santa Cruz, to celebrate the 90th birthday of Albert Whitford, and to discuss the structure and stellar population of the bulge of our Galaxy and other related topics. Present were many of Whitford's lifelong friends and close associates, along with a number of researchers who more recently have been actively working on the central regions of the Galaxy.

The scientific organizing for the meeting consisted of Jay Frogel, Ruth Peterson, George Preston, Michael Rich, Nick Suntzeff, Donald Terndrup, and Bob Kraft (Chair). Local arrangements were supervised by Bob Kraft,

Chief cook & bottle washer


−2.5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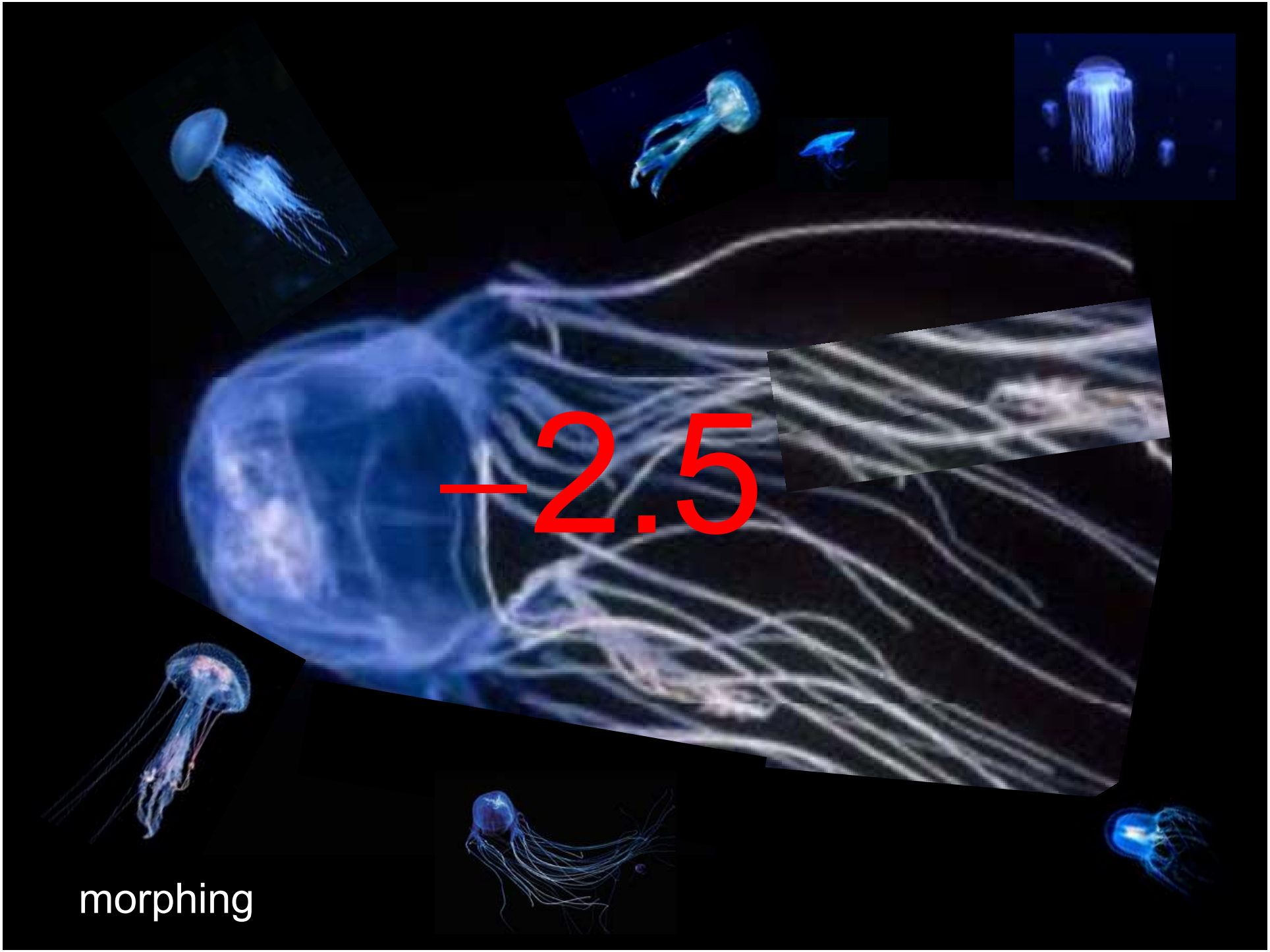
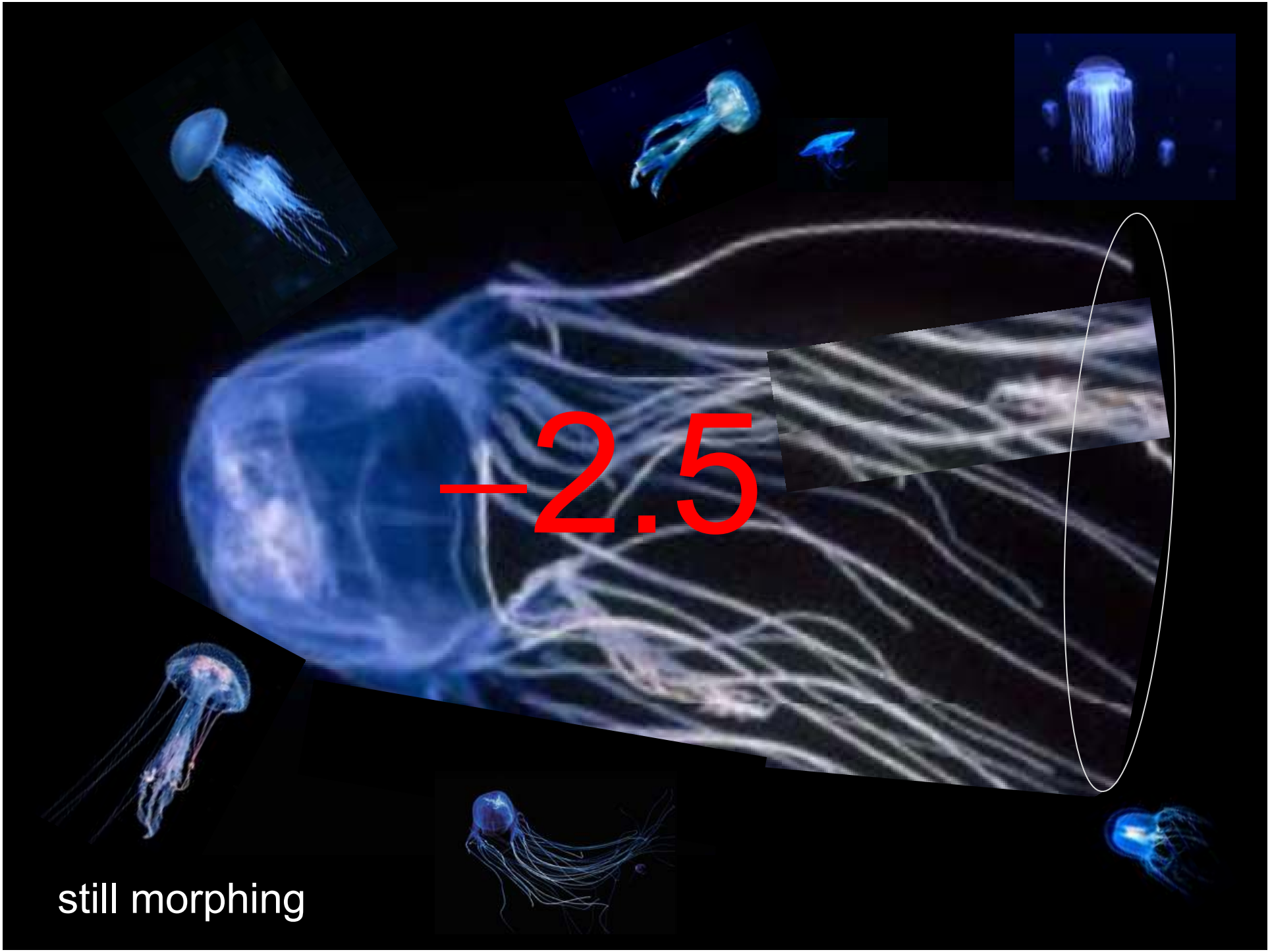
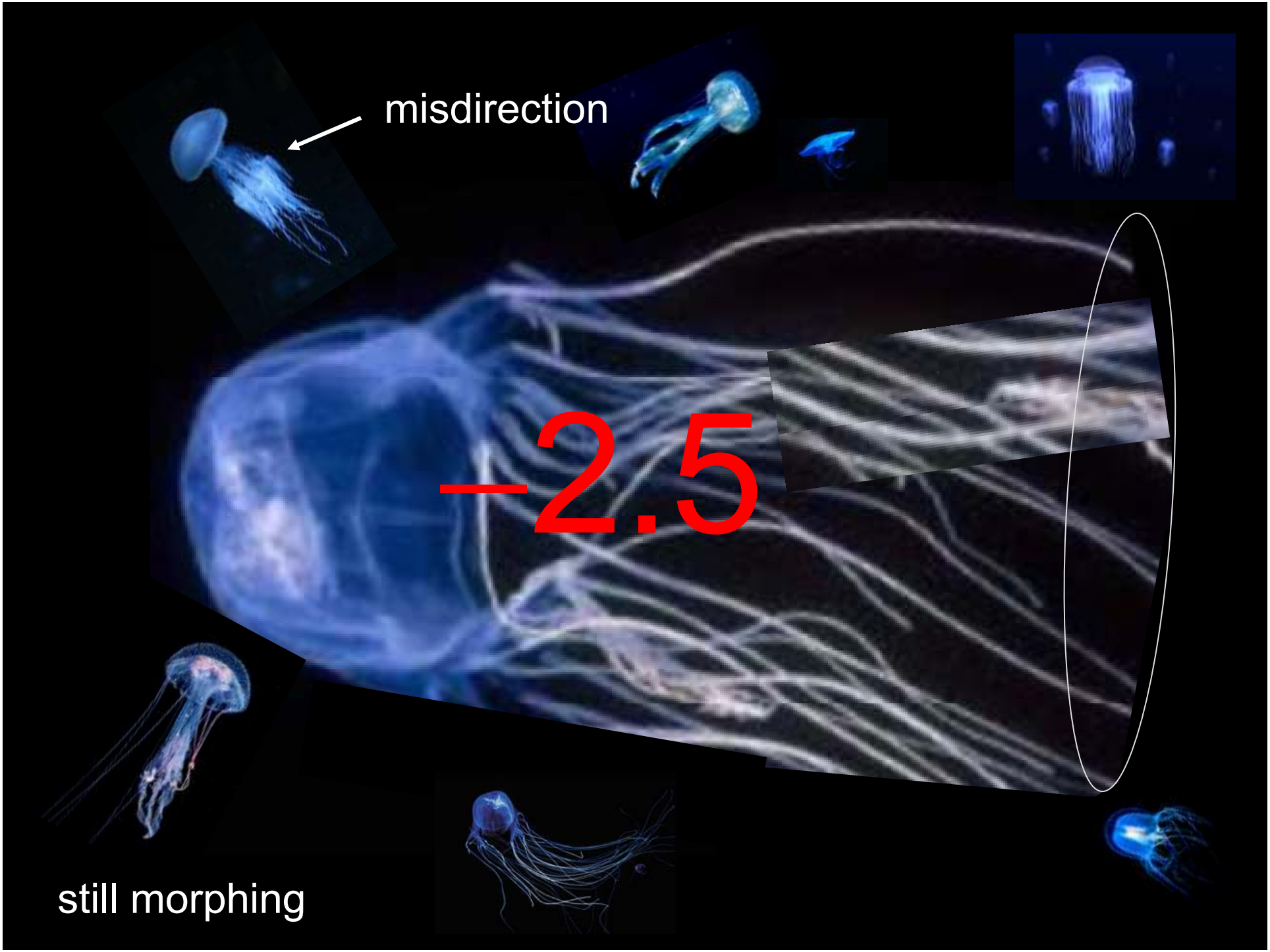
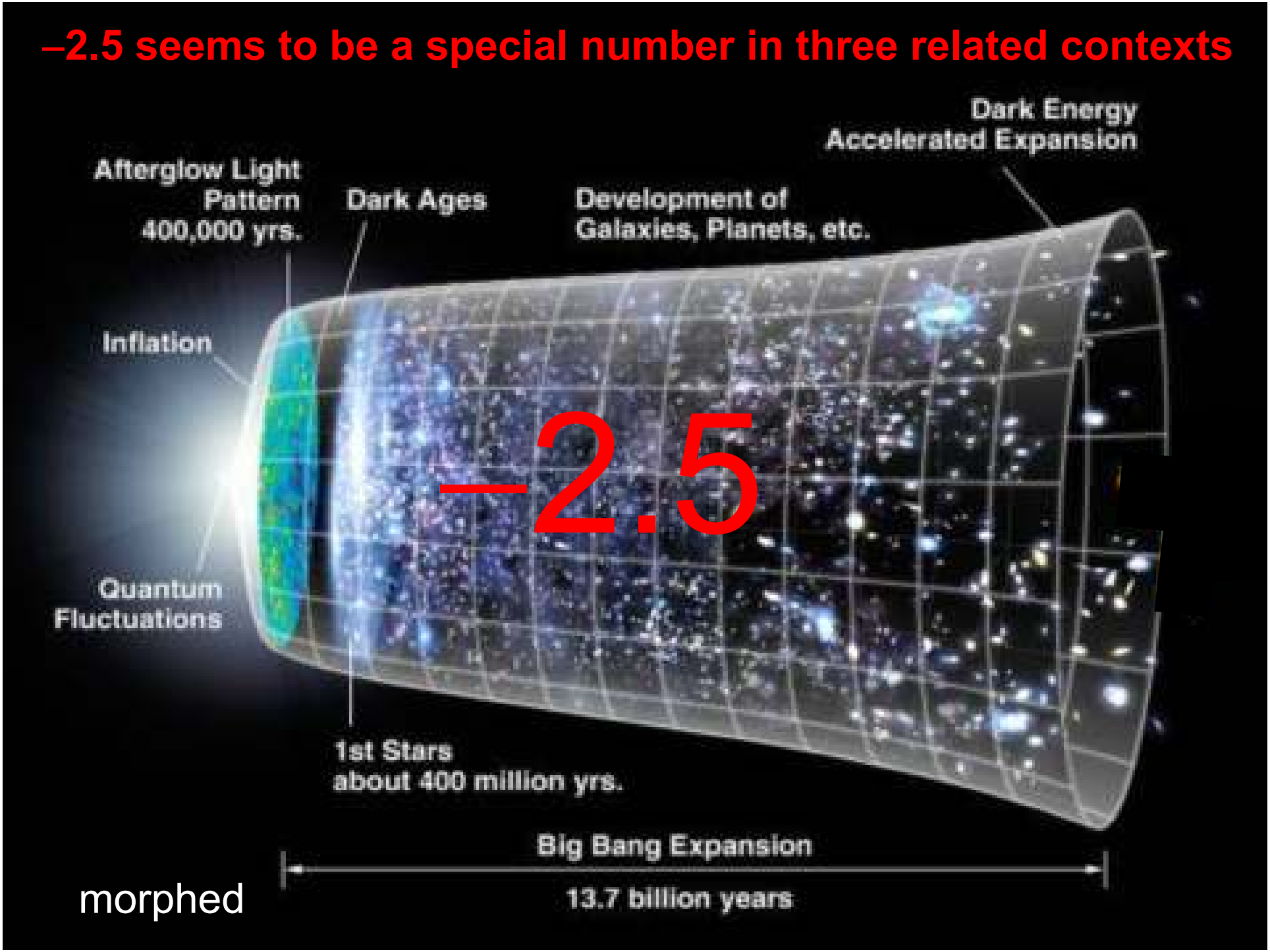

−2.5
morphing


−2.5
still morphing


misdirection
−2.5
still morphing

You can’t imagine where this is going
−2.5
still morphing

–2.5 seems to be a special number in three related contexts



morphed

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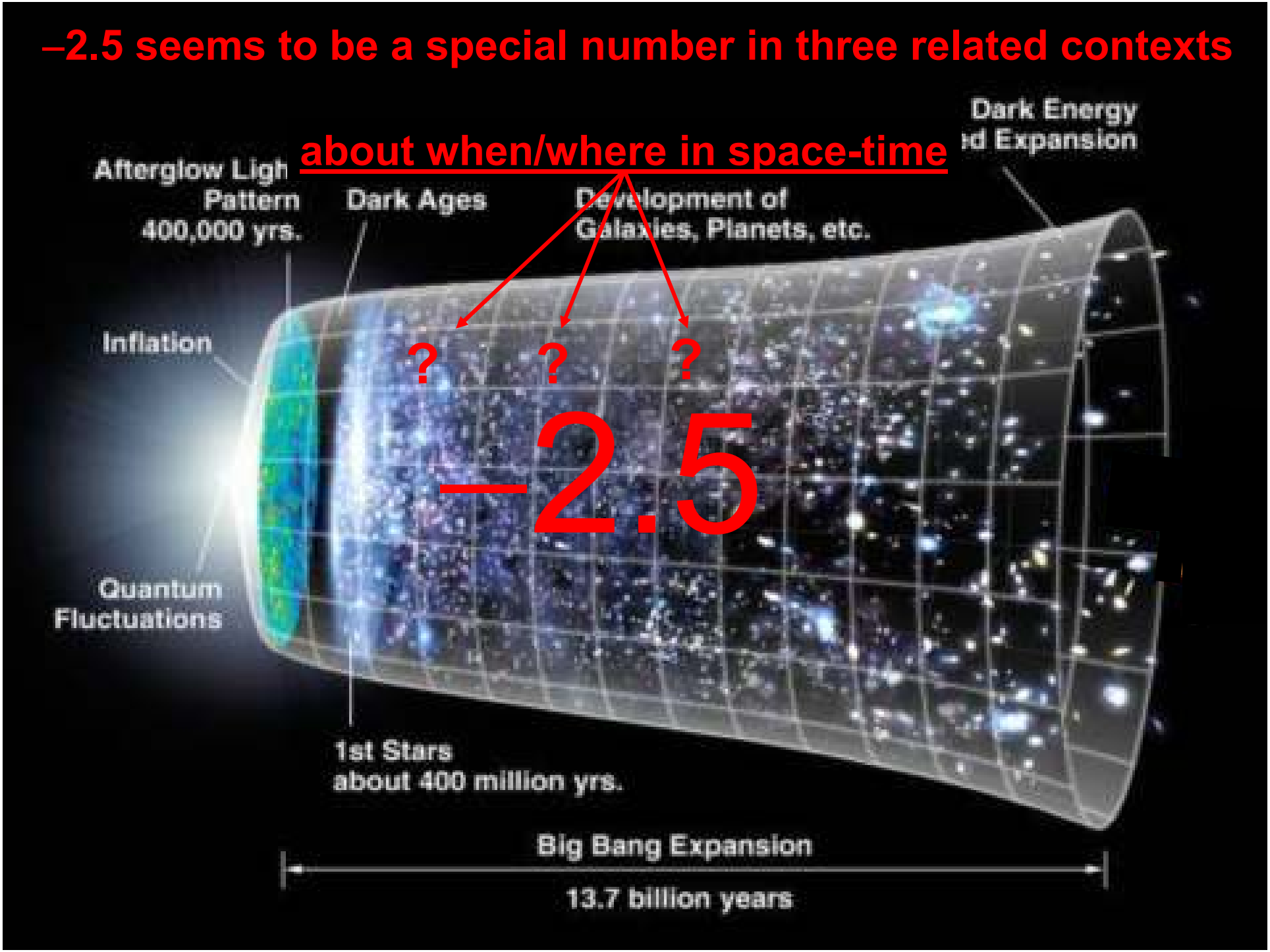
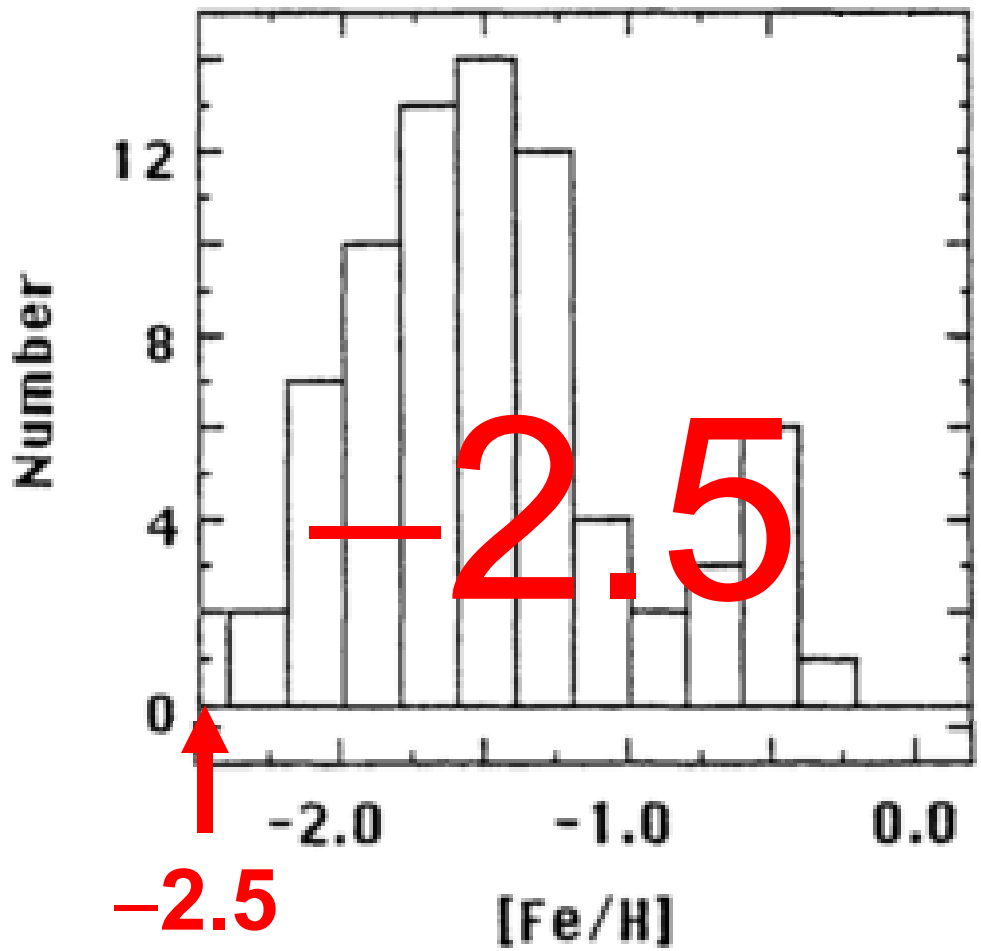


(1) It is an <u>apparent</u> lower bound to the metallicity distribution of the Galactic Halo GCs (Zinn 1989 JRASC)



(1) It is an apparent lower bound to the metallicity distribution

A New Globular Cluster Metallicity Scale Based on the Abundance of Fe II

R. P. KRAFT[1] and I. I. IVANS[2]

Carnegie Observatories Astrophysics Series, Vol. 4: Origin and Evolution of the Elements, 2003

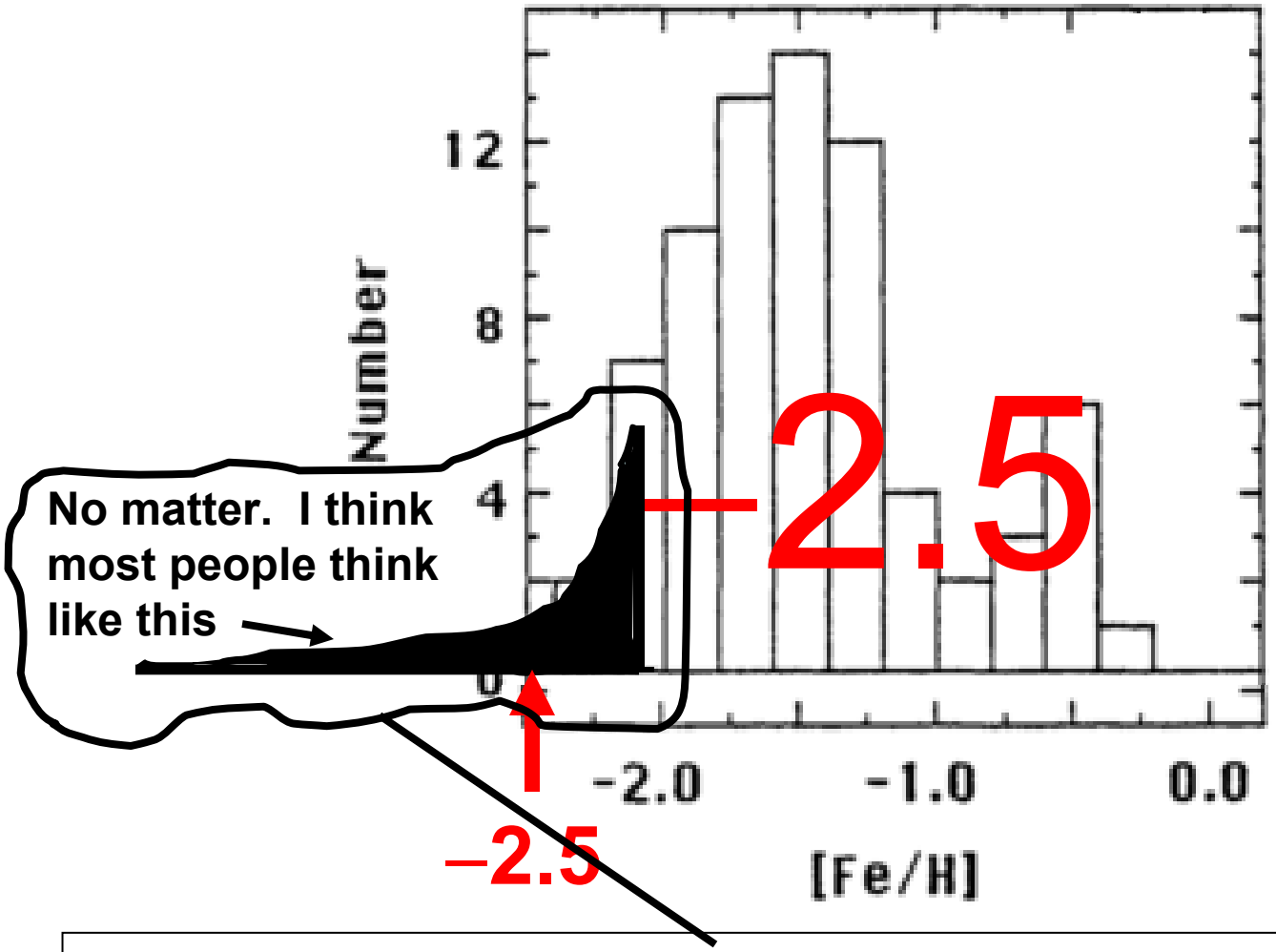
1.8 Conclusions

There exists no "definitive" set of cluster metallicities that are systematically reliable on the 0.05 dex level. Any discussion of cluster abundances (Galactic or extragalactic) must state clearly the underlying assumptions concerning the stellar atmosphere models used; the adopted $T_{\rm eff}$-scale; what is meant by "metallicity" (eg. Fe I? Fe II? or a mean thereof?); what is the method used to derive log g; and the origin of gf-values.

±0.1 dex is the wiggle room, according to Inese & Our Honoree

Is it a significant lower bound? .. Small number statistics, yadda, yadda, yadda

(1) It is an <u>apparent</u> lower bound to the metallicity distribution of the Galactic Halo GCs (Zinn 1989 JRASC)



<u>Is it a significant lower bound?</u> .. Small number statistics, yadda, yadda, yadda

METALLICITY EVOLUTION IN THE EARLY UNIVERSE

Jason X. Prochaska[1] (and Art Wolfe)

Department

Time goes by

(2) It is also an apparent lower bound to abundances in damped Lyα systems at high redshift

Received 1999 October 12; accepted 2000 February 8; published 2000 March 16

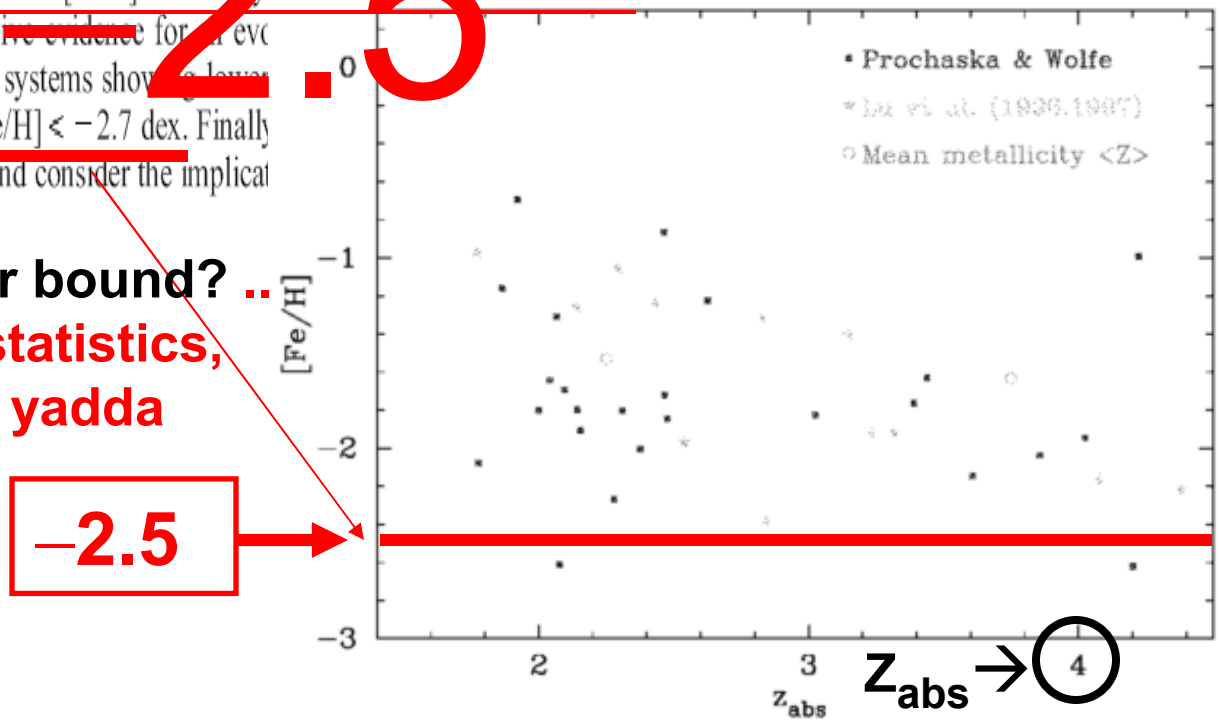
ABSTRACT

Observations of the damped Lyα systems provide direct measurements on the chemical enrichment history of neutral gas in the early universe. In this Letter, we present new measurements for four damped Lyα systems at high redshift. Combining these data with [Fe/H] values culled from the literature, we investigate the metallicity evolution of the universe from $z \approx 1.5$ to 4.5. Contrary to our expectations and the predictions of essentially every chemical evolution model, the N(H I)–weighted mean [Fe/H] metallicity exhibits minimal evolution over this epoch. For the individual systems, we report tentative evidence for [illegible] evolution in the mean and the scatter in [Fe/H], with the higher redshift systems showing lower values. We also note that no damped Lyα system has [Fe/H] < −2.7 dex. Finally, we discuss the effects of small number statistics and dust on our conclusions and consider the implications for chemical evolution in the early universe.

2.5

Significance of this lower bound? ..

Again, small number statistics, more yadda, yadda, yadda



–2.5

METALLICITY EVOLUTION IN THE EARLY UNIVERSE

Jason X. Prochaska[1] *

Ob

Department

* Jason still owes me one US dollar re: "24 steps"

(and Art Wolfe)

(2) It is also an apparent lower bound to abundances in damped Lyα systems at high redshift

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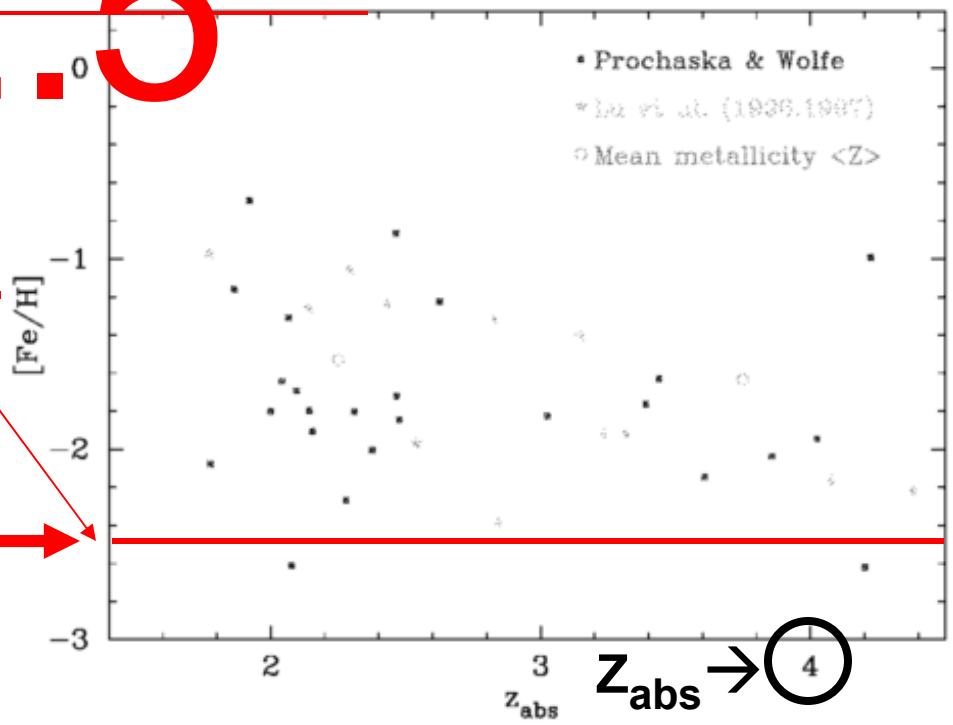
Observations of the damped Lyα systems provide direct measurements on the chemical enrichment history of neutral gas in the early universe. In this Letter, we present new measurements for four damped Lyα systems at high redshift. Combining these data with [Fe/H] values culled from the literature, we investigate the metallicity evolution of the universe from $z \approx 1.5$ to 4.5. Contrary to our expectations and the predictions of essentially every chemical evolution model, the N(H i)–weighted mean [Fe/H] metallicity exhibits minimal evolution over this epoch. For the individual systems, we report tentative evidence for an evolution in the mean and the scatter in [Fe/H], with the higher redshift systems showing lower values. We also note that no damped Lyα system has [Fe/H] < -2.7 dex. Finally, we discuss the effects of small number statistics and dust on our conclusions and consider the implications for chemical evolution in the early universe.

Significance of this lower bound? .. Again, small number statistics, more yadda, yadda, yadda

–2.5

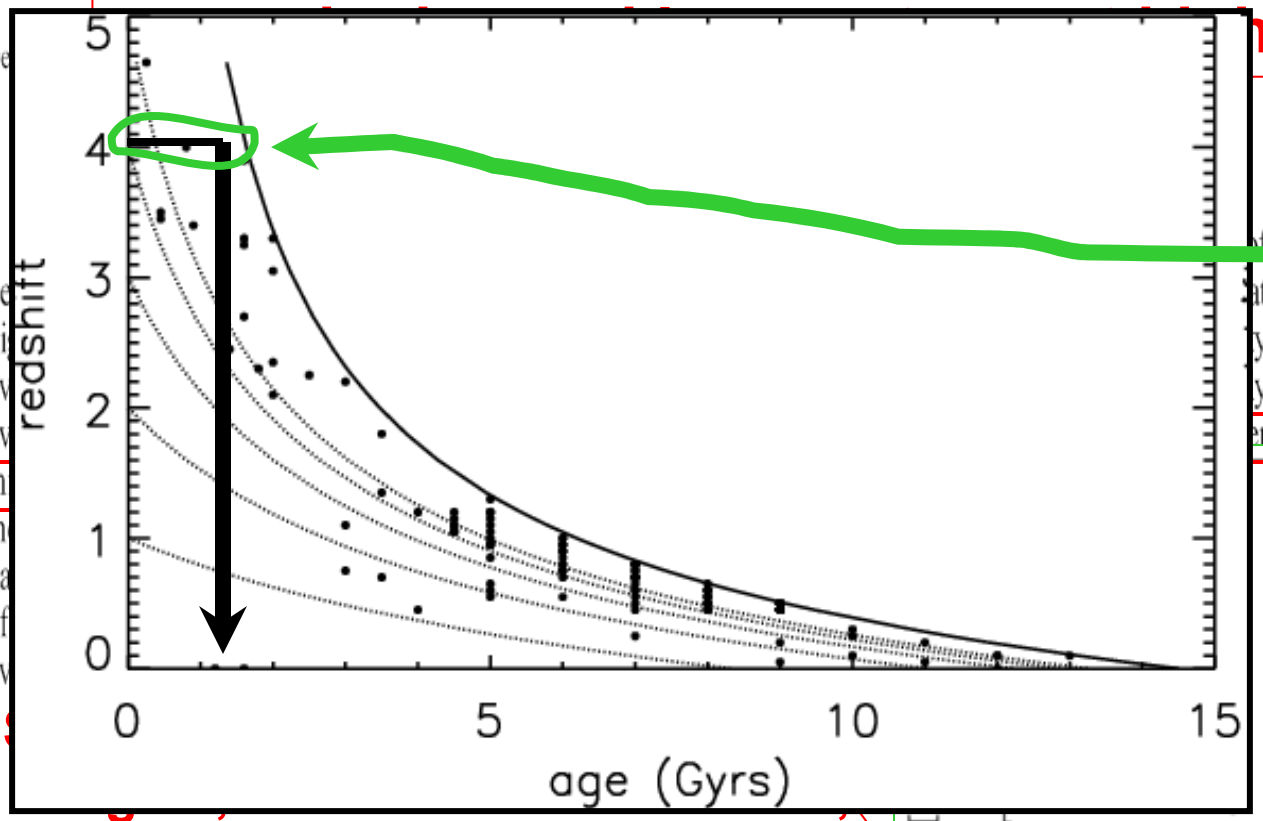


METALLICITY EVOLUTION IN THE EARLY UNIVERSE

Jason X. Prochaska[1] (and Art Wolfe)

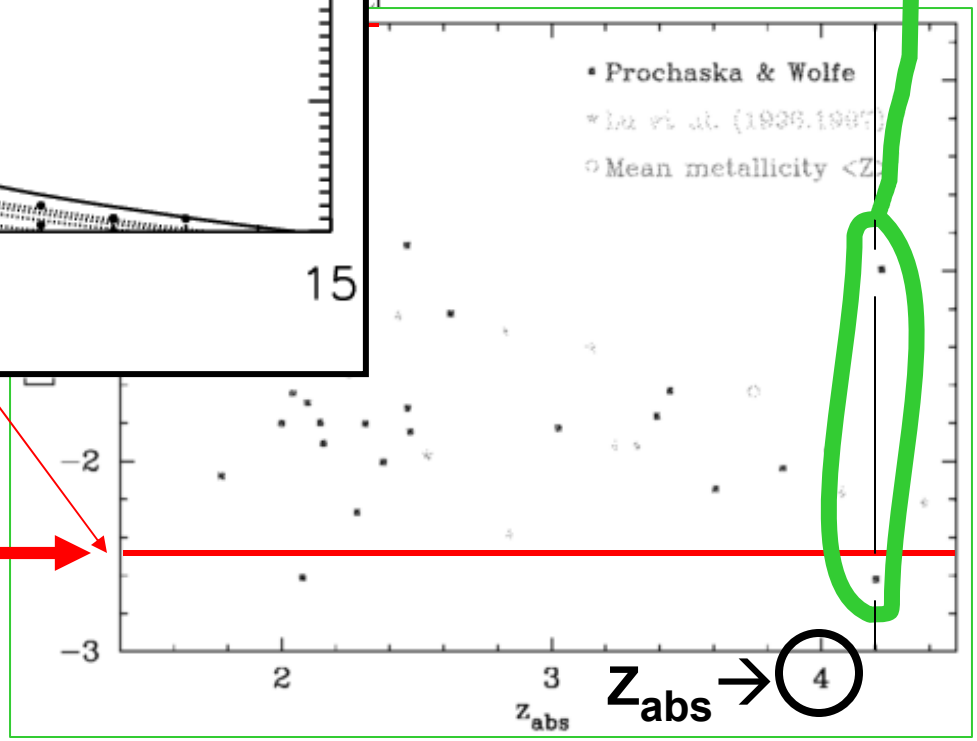
(2) It is also an apparent lower bound to abundances

redshift



more yadda, yadda, yadda

–2.5



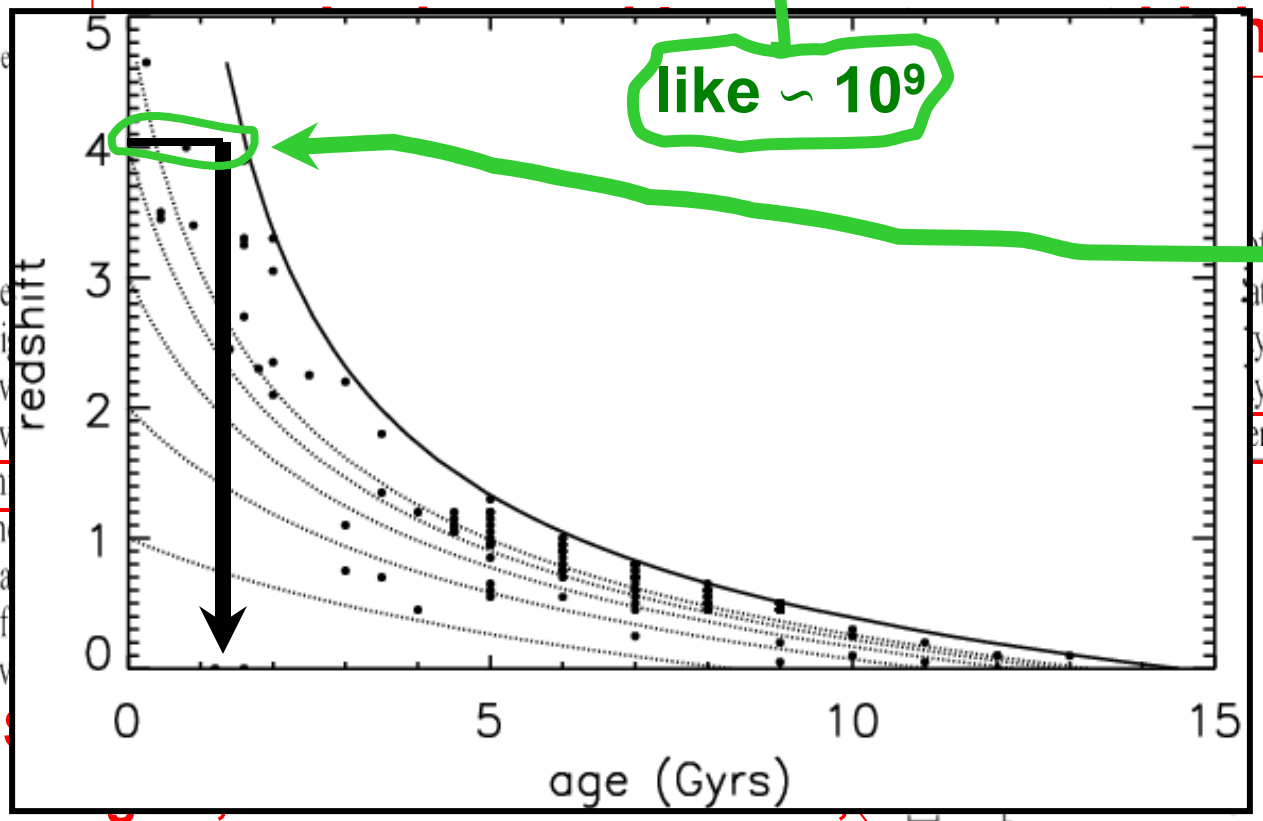
METALLICITY EVOLUTION IN THE EARLY UNIVERSE

Jason X. Prochaska[1] (and Art Wolfe)

(2) It is also an apparent lower bound to abundances

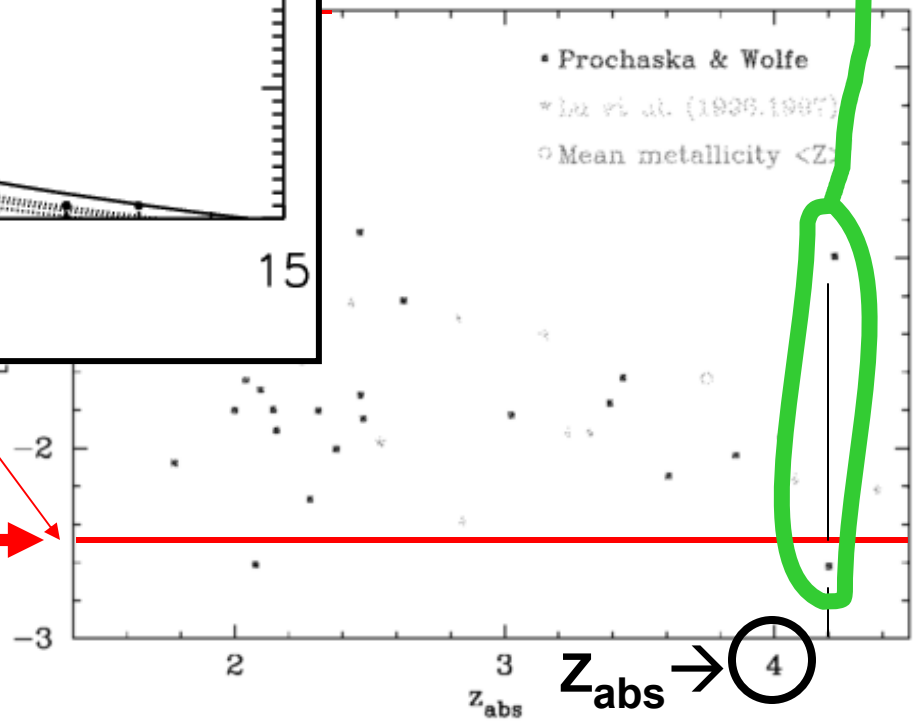
n redshift

like ~ 10^9



more yadda, yadda, yadda

–2.5

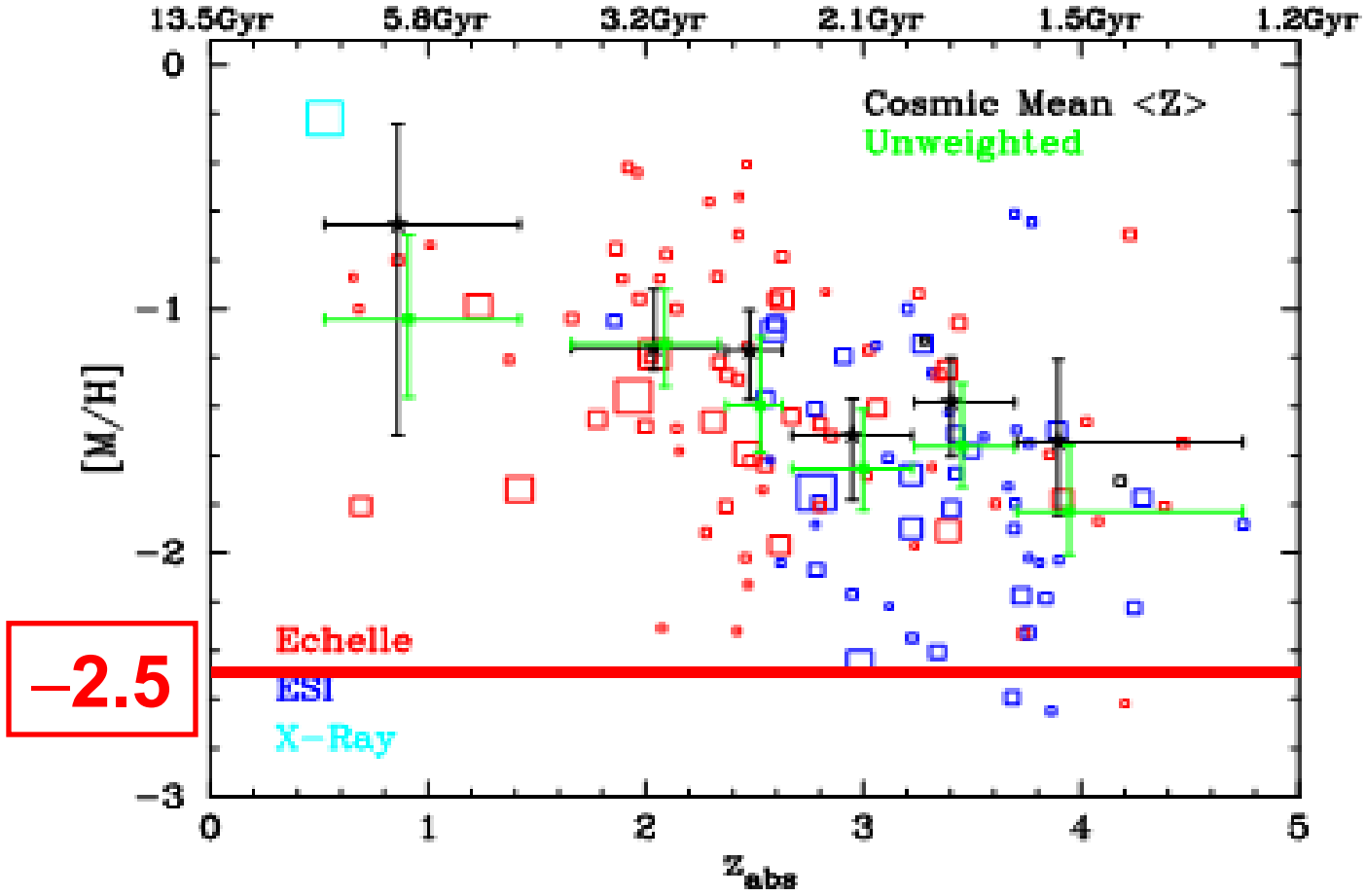


Here is a Prochaska 2004 update

Chemical Abundances in the Damped Lyα Systems

JASON X. PROCHASKA
UCO/Lick Observatories

Carnegie Observatories Astrophysics Series, Vol. 4: Origin and Evolution of the Elements



−2.5

xhttp://pnm.itp.ucsb.edu/online/stars_c07/wolfe/pdf/Wolfe_StarFormationConf_KITP.pdf

KITP Conference: Star Formation, Then and Now: Friday, August 17, 2007

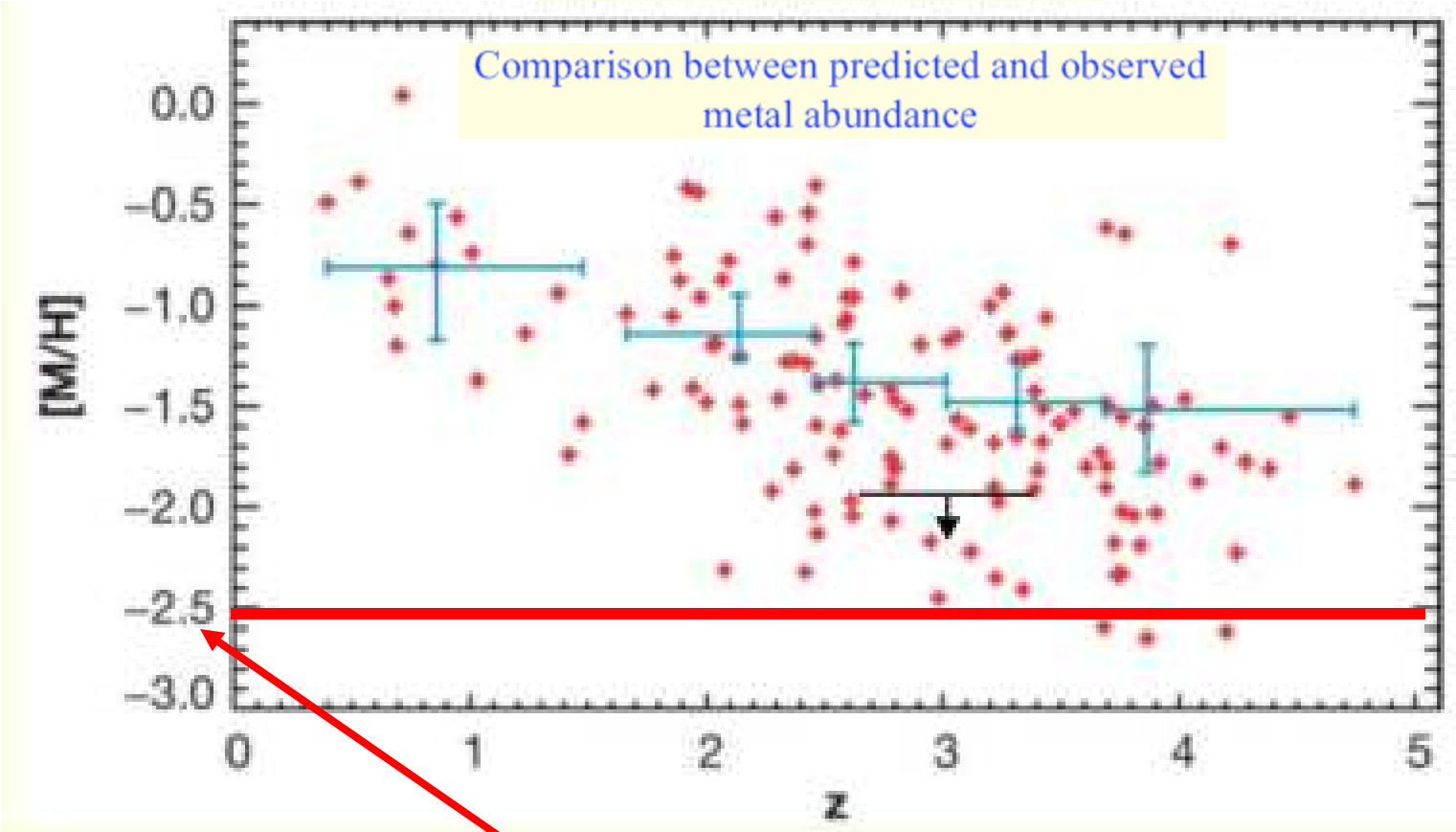
Bimodality in Damped Lyα Systems

Art Wolfe

Hsiao-Wen Chen--U. Chicago

Regina Jorgenson--U. C. San Diego

Jason X. Prochaska--U. C. Santa Cruz



And Wolfe et al presented similar data at KITP in 2007, so it looks like the J&P 2000 conclusion still stands.

(3a) Finally, It is the location of abrupt slope-changes in chemical evolution diagrams for stars of the Galactic halo.

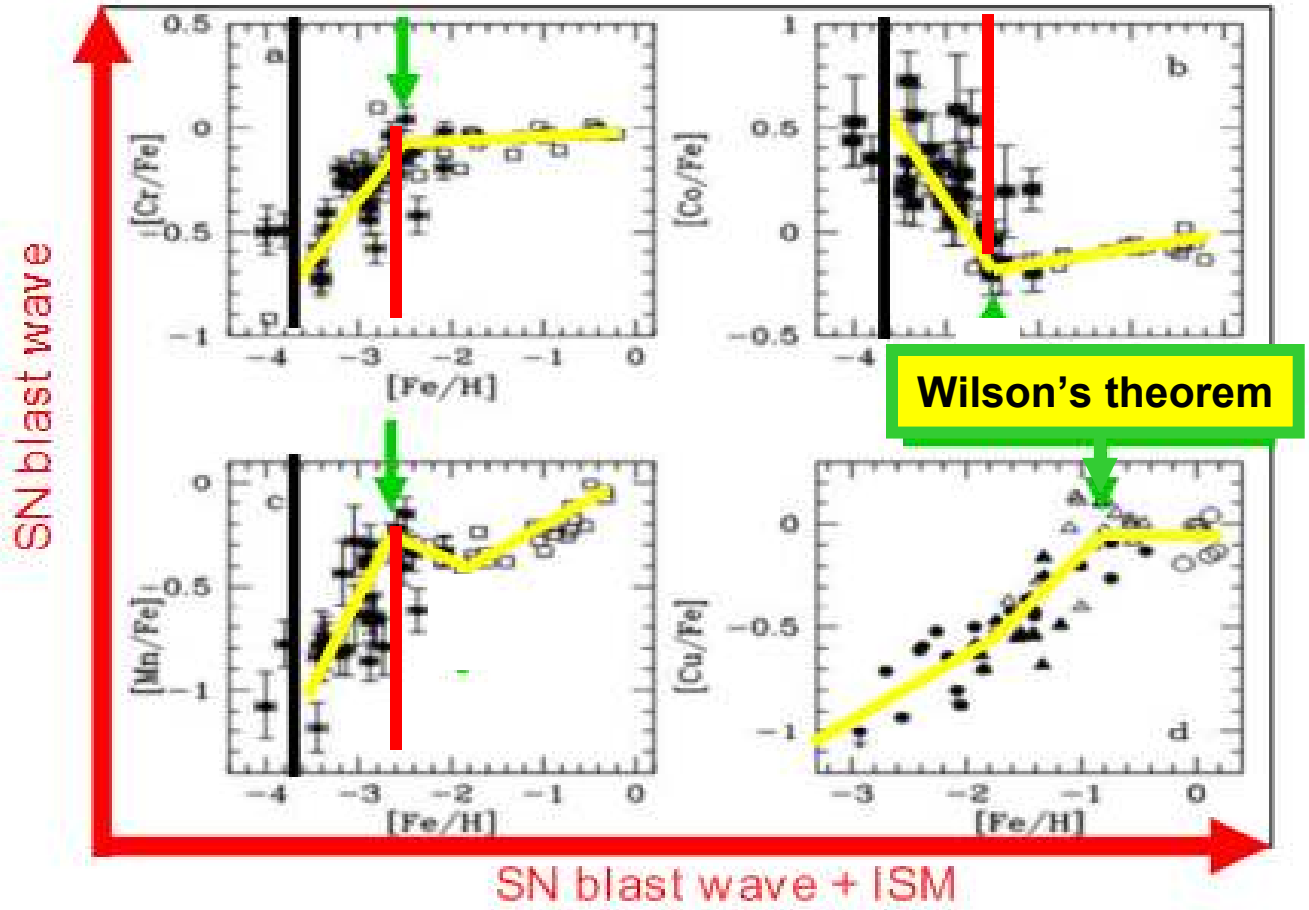
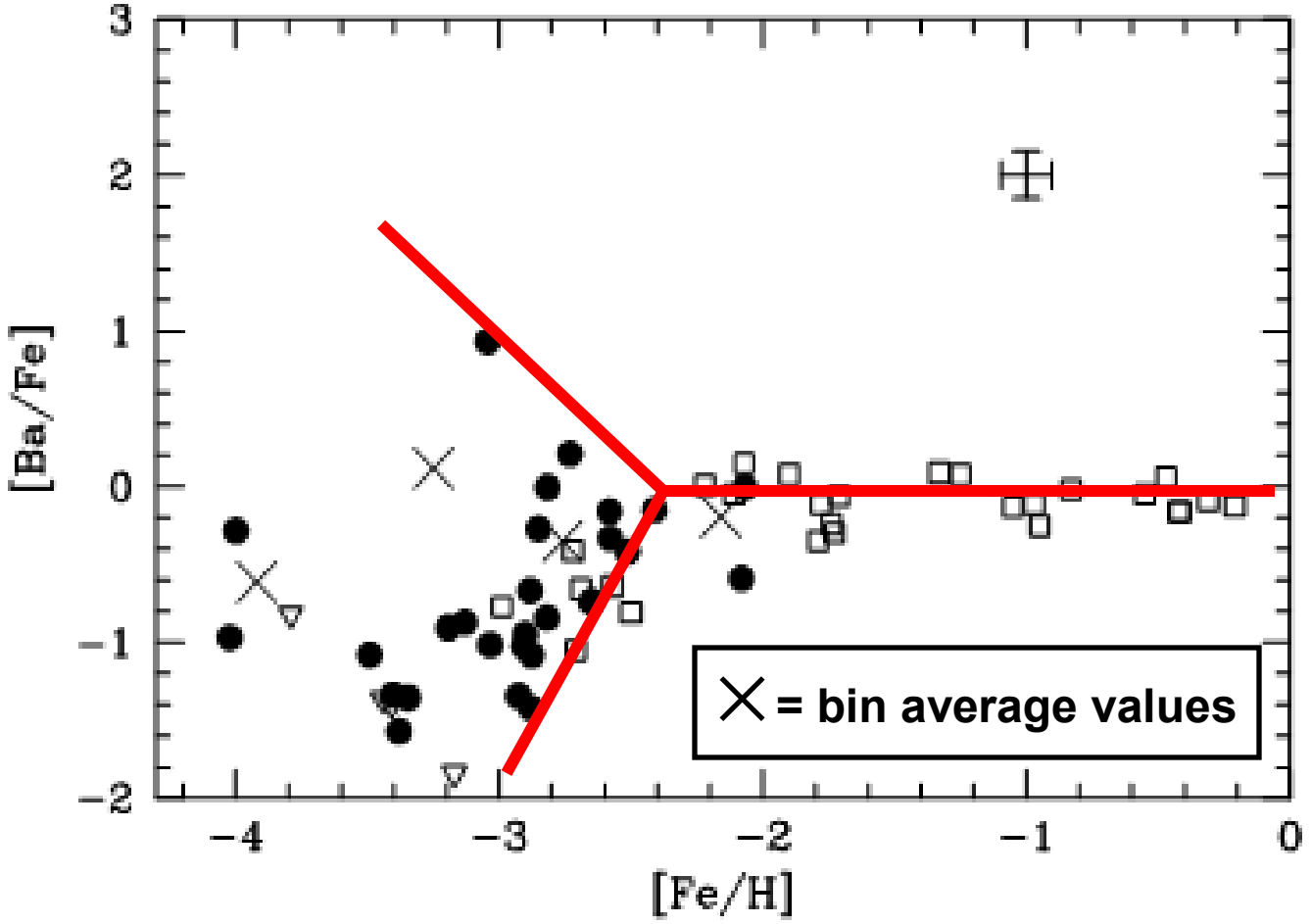


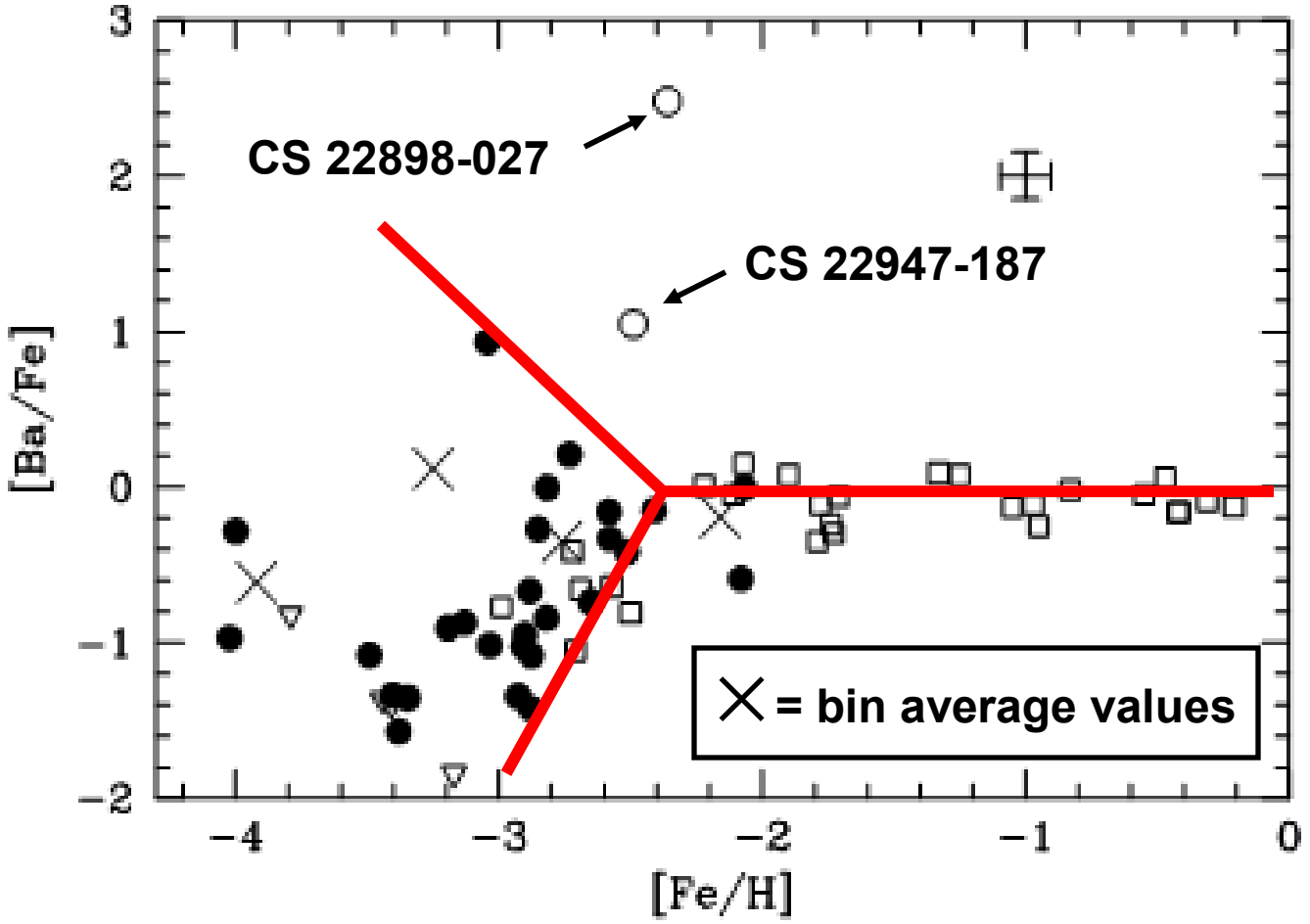
Fig. 1 Logarithmic element to Fe ratios n units of the solar va ues are plotted versus logarithmic Fe/H ratios, a so in solar units for four Fe-peak elements (from McWilliam et al 1995, AJ 109, 2757). Ye ow ine-segments are eye-fitted empirical regressions. Green arrows mark changes in slope. Black vertical lines near [Fe/H] = -3.6 denote a speculative imit be ow which [Fe/H] is no onger a surrogate c ock (see Audouze & S lk 1995, ApJ, 451 L49) The bold, red coordinate axes are included to dramat ze the problem of expla ning why element-to-Fe ratios are correlated with [Fe/H].

(3b) And, approximately, it is where the Barium-to-Iron abundance ratio converges to its present-day solar value.



ANDREW MC WILLIAM THE ASTRONOMICAL JOURNAL, 115:1640–1647, 1998.

(3c) Pollution by AGB binary companions can produce occasional carbon stars with even larger Barium excesses



ANDREW MC WILLIAM THE ASTRONOMICAL JOURNAL, 115:1640–1647, 1998.

Accepting

Prompt Initial Enrichment (PIE)

by super-massive stars (SMS) during first 10^9 years

maybe

changes in nature of Chemical Evolution at [Fe/H] = –2.5

are due to the transition

SMS nucleosynthesis → "ordinary" SN nucleosynthesis.

Cloud collapse → SMS (or TH-IMF) → PIE to [Fe/H] ~ –3

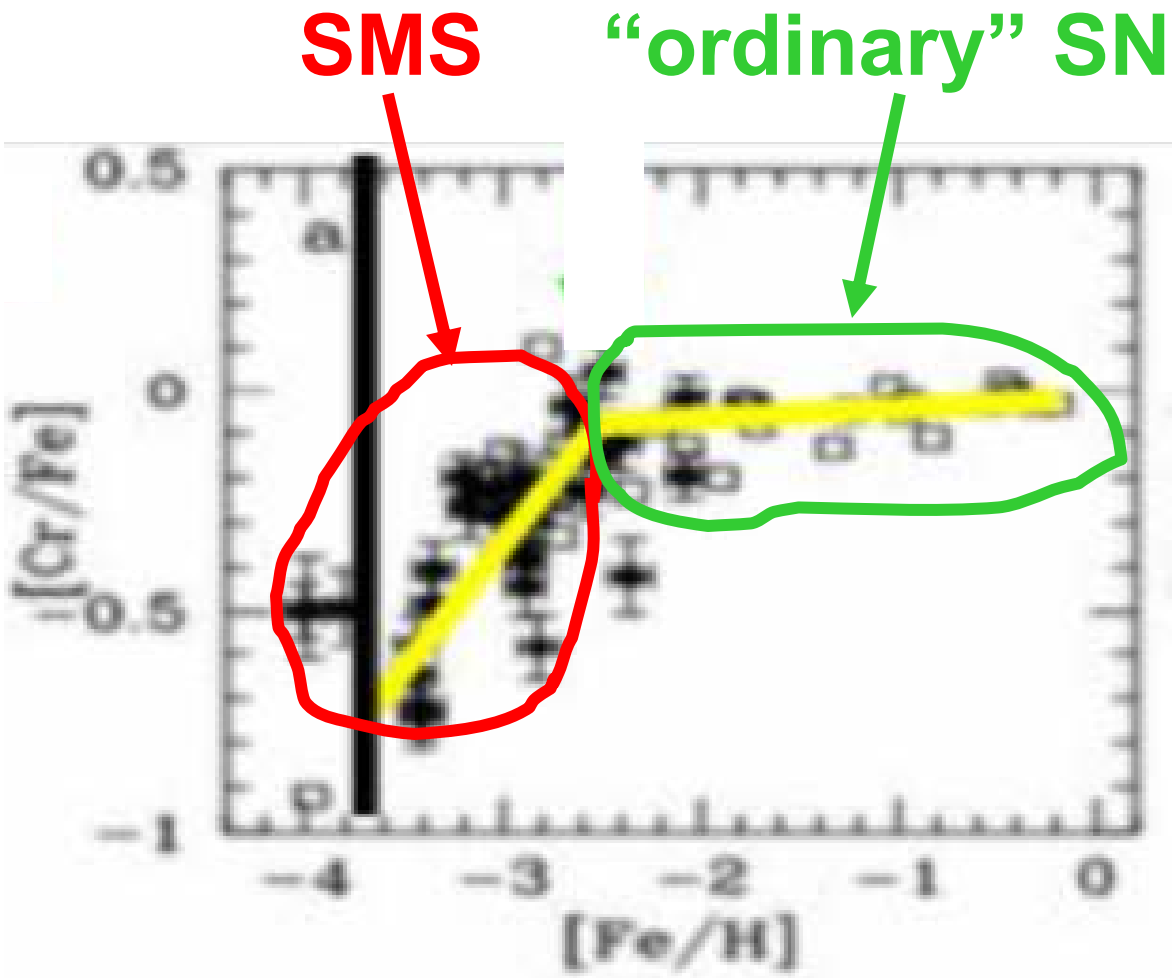
↓

Metal enrichment alters mode of cloud collapse

↓

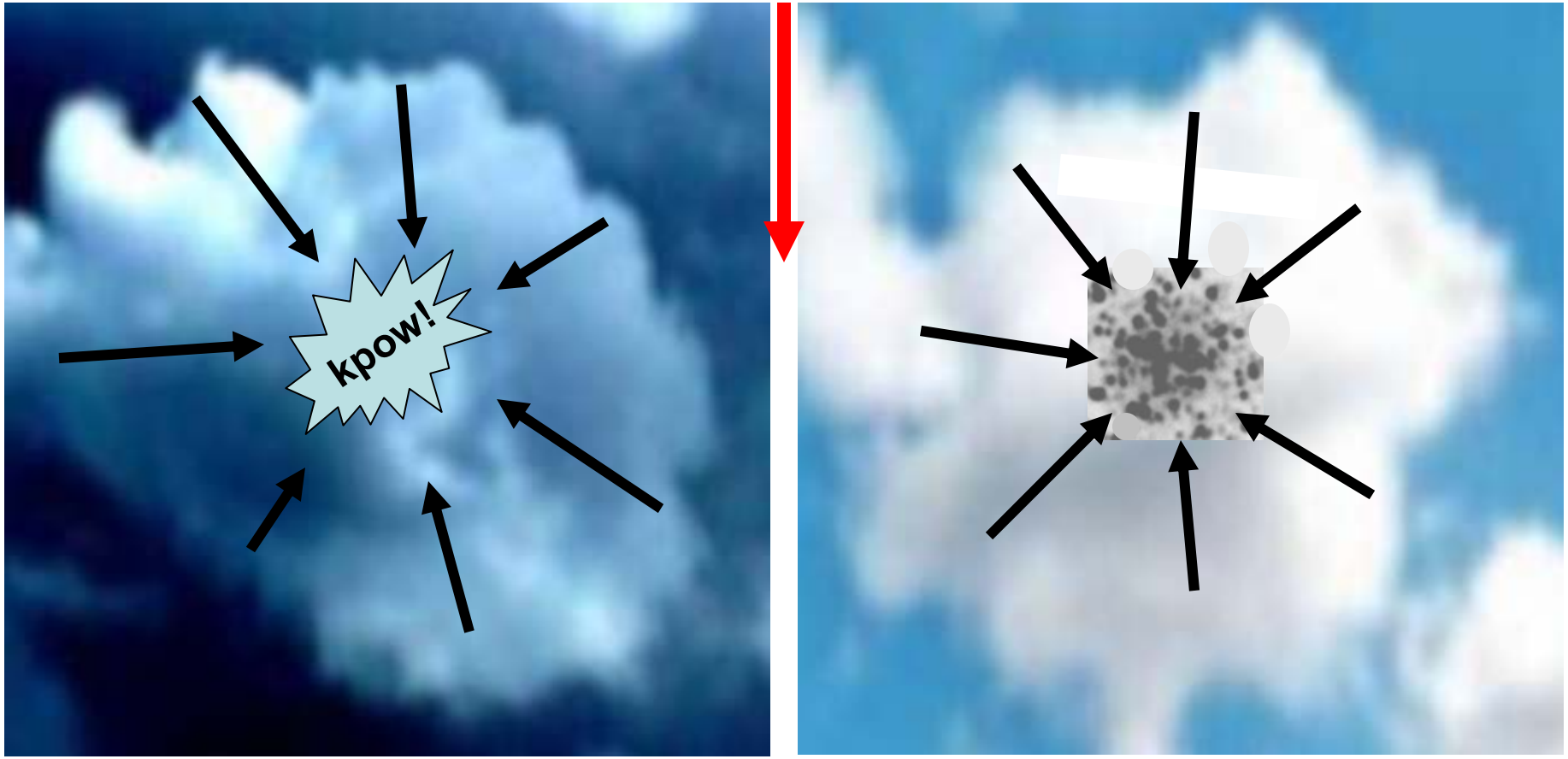
Cloud collapse → fractionation → GCs instead of SMS

So, { Different kind of progenitors
Different kind of SN
Different kind of Chem. Evol. } after [Fe/H] ≈ – 2.5



How physics of star formation at this epoch effects this transition is above my pay grade.

–2.7



< –3.0

> –2.5

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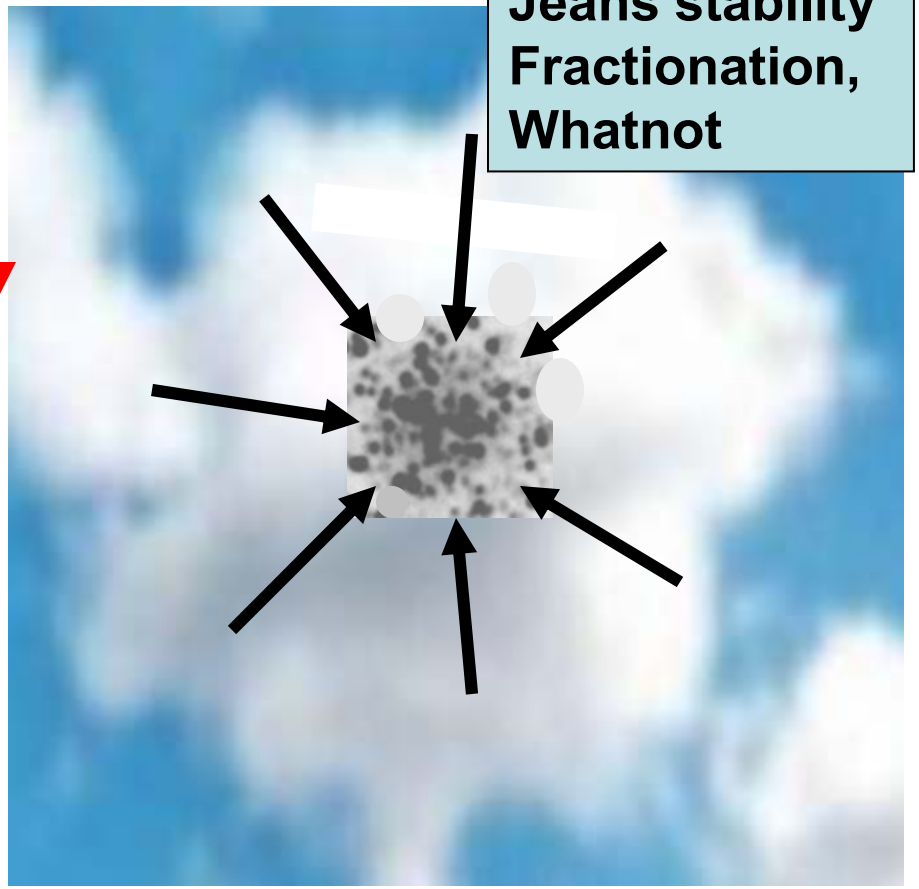

Cooling agents
Jeans stability
Fractionation,
Whatnot

< –3.0

> –2.5

An aside: supermassive stars are old stuff, of course – at least 34 years old

Linear Series of Stellar Models. VI. Supermassive Stars

by

B. Paczyński

N. Copernicus Astronomical Center, Polish Academy of Sciences, Warsaw

and

M. Różyczka

Warsaw University Observatory

Received February 22, 1977

1977

These people think big!
(log M, not M, folks!)

ABSTRACT

Linear series of stellar models on hydrogen burning main sequence is constructed for Population I composition ($X = 0.7$, $Y = 0.27$, $Z = 0.03$) for masses in the range $1.8 \leqslant \log M/M_\odot \leqslant 12.0$. No terminating point is found in the supermassive star region. For $\log M/M_\odot > 9$ the main sequence models develope a giant type structure and various assumptions underlying our computations become invalid.

Models with $\log M/M_\odot > 5.7$ are known to be thermally unstable even though there is no turning point of the linear series. This phenomenon is caused by the onset of dynamical instability at the same mass.

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by

B. Paczyński

A bit of ancient Lick Observatory history :
Paczynski, a graduate student of Warsaw University, worked as a research assistant at LO in 1962-63.

Warsaw University Observatory

Received February 22, 1977

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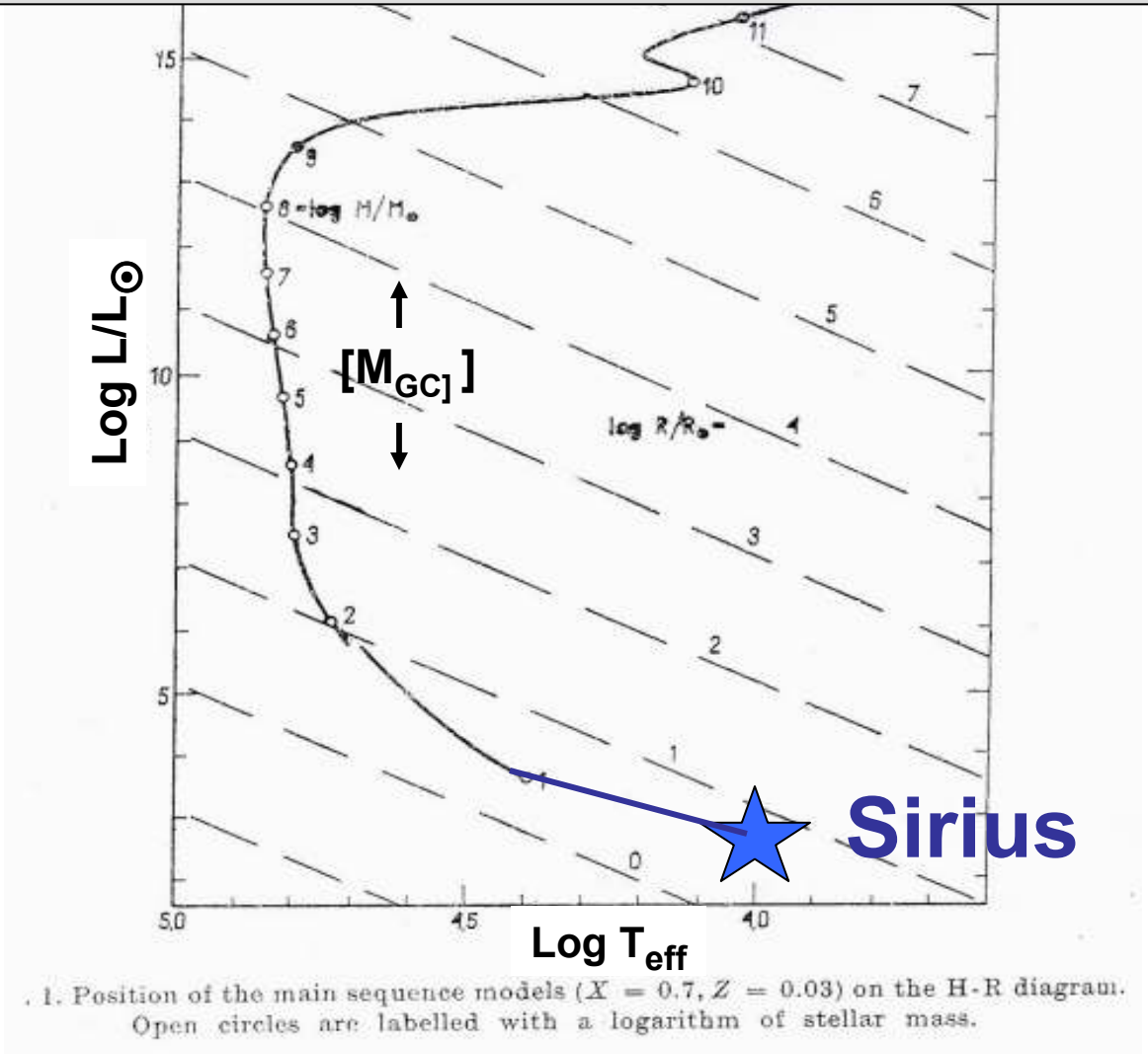
With regard to their SMS main sequence I quote the authors:

"For masses greater than 10^9 $M_\odot$, main sequence models develop a giant type structure."



. 1. Position of the main sequence models ($X = 0.7, Z = 0.03$) on the H-R diagram. Open circles are labelled with a logarithm of stellar mass.

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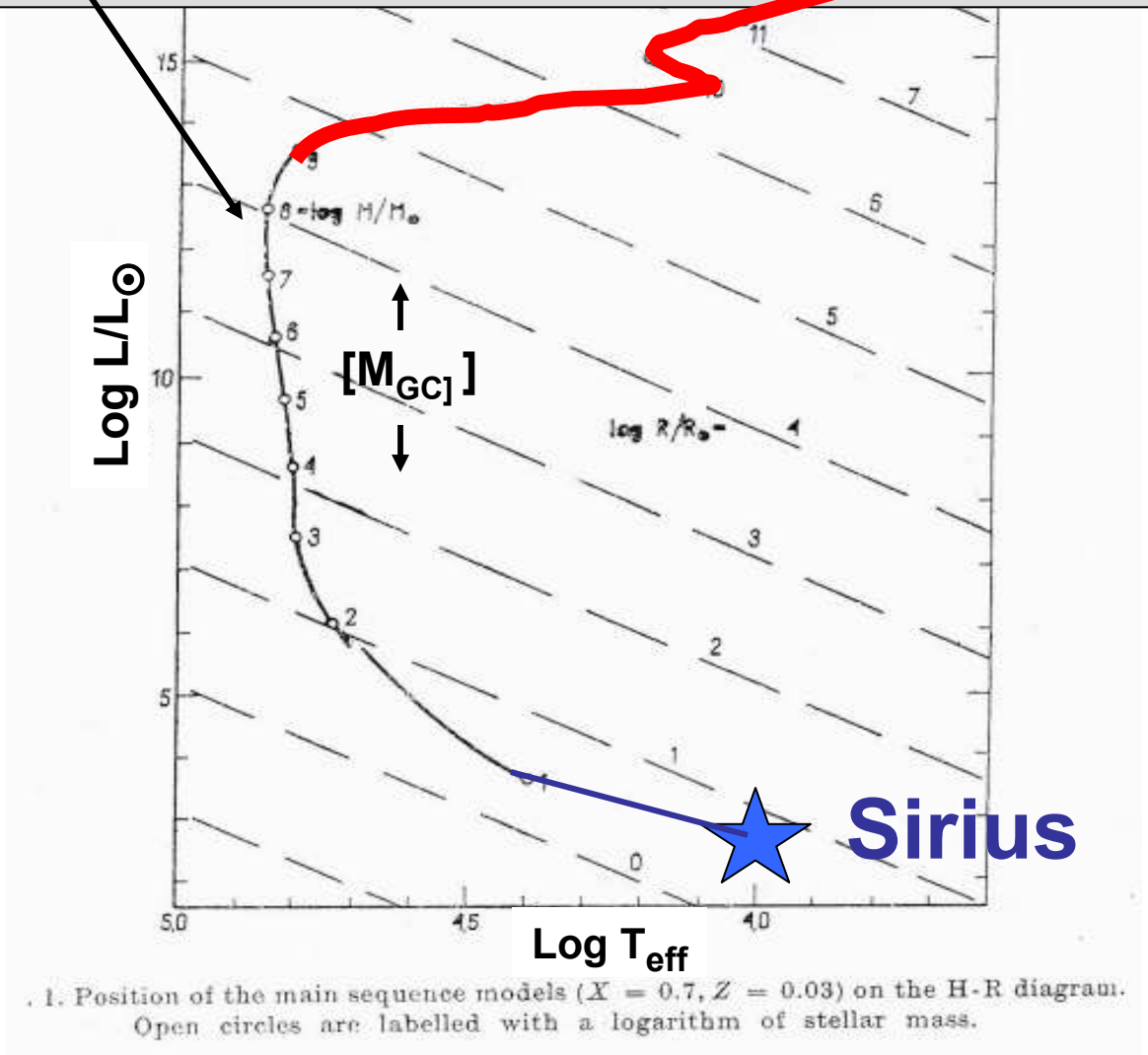

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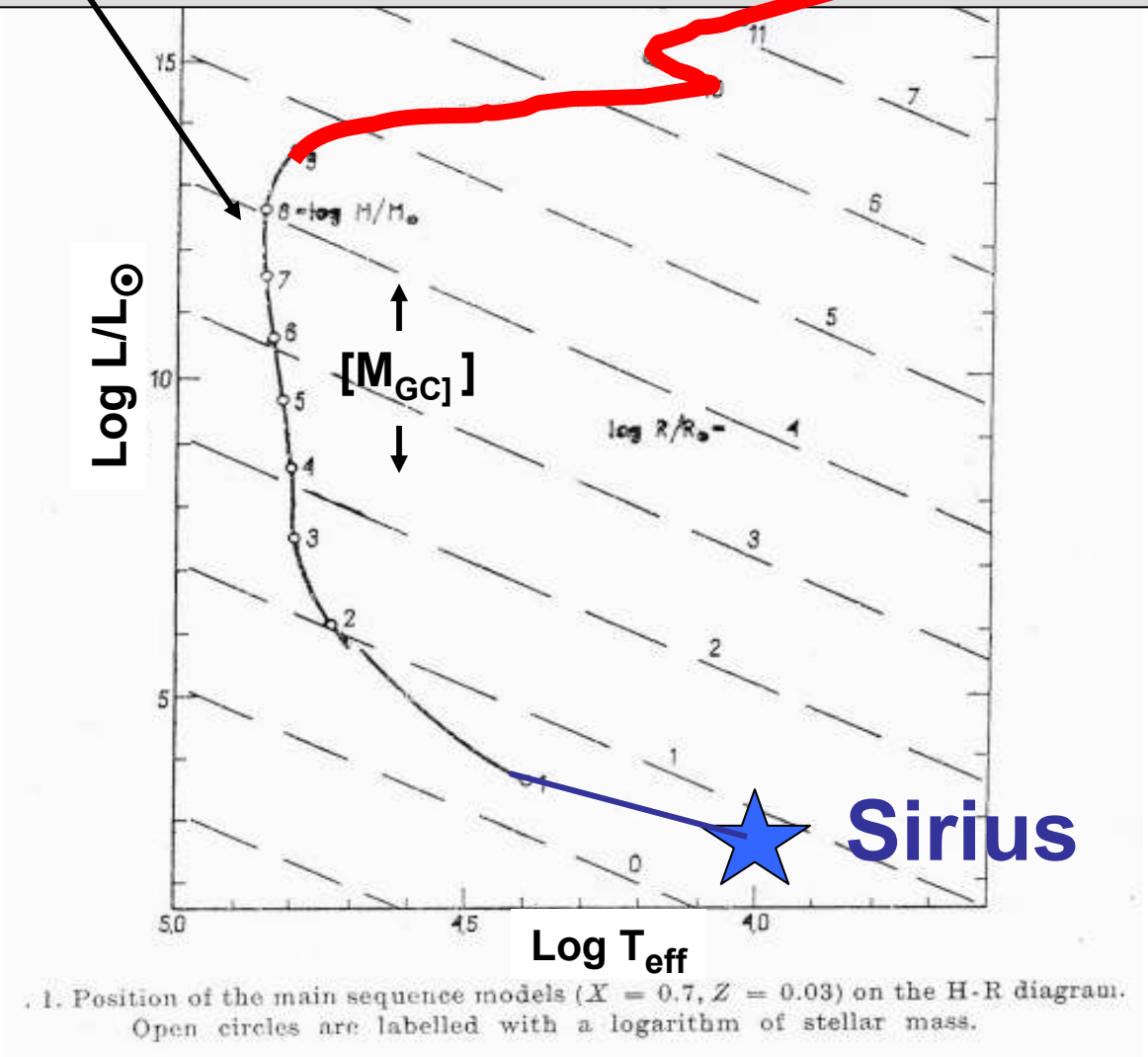
Oh…. OK.



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Now,

we turn to the globular clusters & our honoree

Mrr. Krraft,

as his mentorr Otto Strruve called him.

As we have learned during this meeting

Globular cluster stars rank among the great mysteries of the world

Globular cluster stars rank among the great mysteries of the world

creators of such mysteries

Leonardo da Vinci

Pierre de Fermat

Sergei N. Blazhko

Pieter Th. Oosterhoff

Sidney van den Bergh

Robert P. You-Know-Who

Is she or isn't she?

1519

Mona Lisa's smile a m
by **Ewen Callaway**

If you have been puzzle e's ra
moment and serious the are over. It
happens because our e the brain
about her smile. Differe
categories of informatio
encode data about an o
in the visual field.

The Mystery of Mona Lisa's Smile Linked to Flickering Eyes

The Italians have a word to explain Mona Lisa's smi
sfumato. It means blurry, ambiguous and up to the imagination.

Neuroscientists at the Institute of Neuroscience in Alicante, Spain claim to have solved the mystery as to why some eople see Mona Lisa's smile ome don't.

Mona Lisa's smile mystery solved

Who is *Mona Lisa*?
Many questions arose o
of the lady in the portrait
which means "the ligh ,
La Joconde, carries a ghts
and theories about the *Mona Lisa*'s smile. One popular theory
suggests that the lady is the Duchess of Milan, Isabella of Aragon.

And who was she?

Art Glossary: *Sfumato* -- Painting Techniques *Sfumato*

painting.about.com/od/artglossaryz/g/bldef*sfumato*.htm - Cached Similar
An explanation of what the painting technique *sfumato* involves.

Sfumato and Chiaroscuro -- Painting in the Style of Old Masters ...

painting.about.com/od/oldmasterstechniques/a/*sfumato*_chiaros.htm - Cached Similar
Don't be kept in the dark by these two important terms, *sfumato* and ...
Show more results from about.com

Sfumato - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/*Sfumato* - Cached Similar
Detail of the face of Mona Lisa showing the use of *sfumato*, particularly in the shading ...
Renaissance Art: A Topical Dictionary. Greenwood Press. pp. 263. ...

Glossary of *Art* Terms and Definitions

www.finearttouch.com/Glossary_of_Art_Terms_and_Definitions.html - Cached Similar
Sep 29, 2006 ... *sfumato* - The term *sfumato* was coined by Italian Renaissance artist, Leonardo da Vinci, and refers to a fine art painting technique of ...

sfumato (painting technique) -- Britannica Online Encyclopedia

www.britannica.com/EBchecked/topic/537471/*sfumato* - Cached Similar
Facts about *sfumato*: development during Renaissance, as discussed in Western painting (art). Leonardo da Vinci: No Additional Content ...

sfumato: Definition from Answers.com

www.answers.com › Library › Literature & Language - Cached Similar
sfumato n. The blurring or softening of sharp outlines in painting by subtle and ... A soft focus in art created by blurring the light and dark edges. ...

Is she or isn't she?

1519

Mona Lisa's smile a m
by

If y
mo
hap
abo
cat
encode data about an o
in the visual field.

I just had to include da Vinci after I learned about "sfumato". What a wonderful word!

The Italians have a word to exp
sfumato. It means blurry, ambiguous
(just like lots of contemporary astrophysics - GWP)

sa's Smile
s
d up to the imagination.

Neuroscientists at the Institute of Neuroscience in Alicante, Spain claim to have solved the mystery as to why some eople see Mona Lisa's smile me don't.

Mona Lisa's smile mystery solved

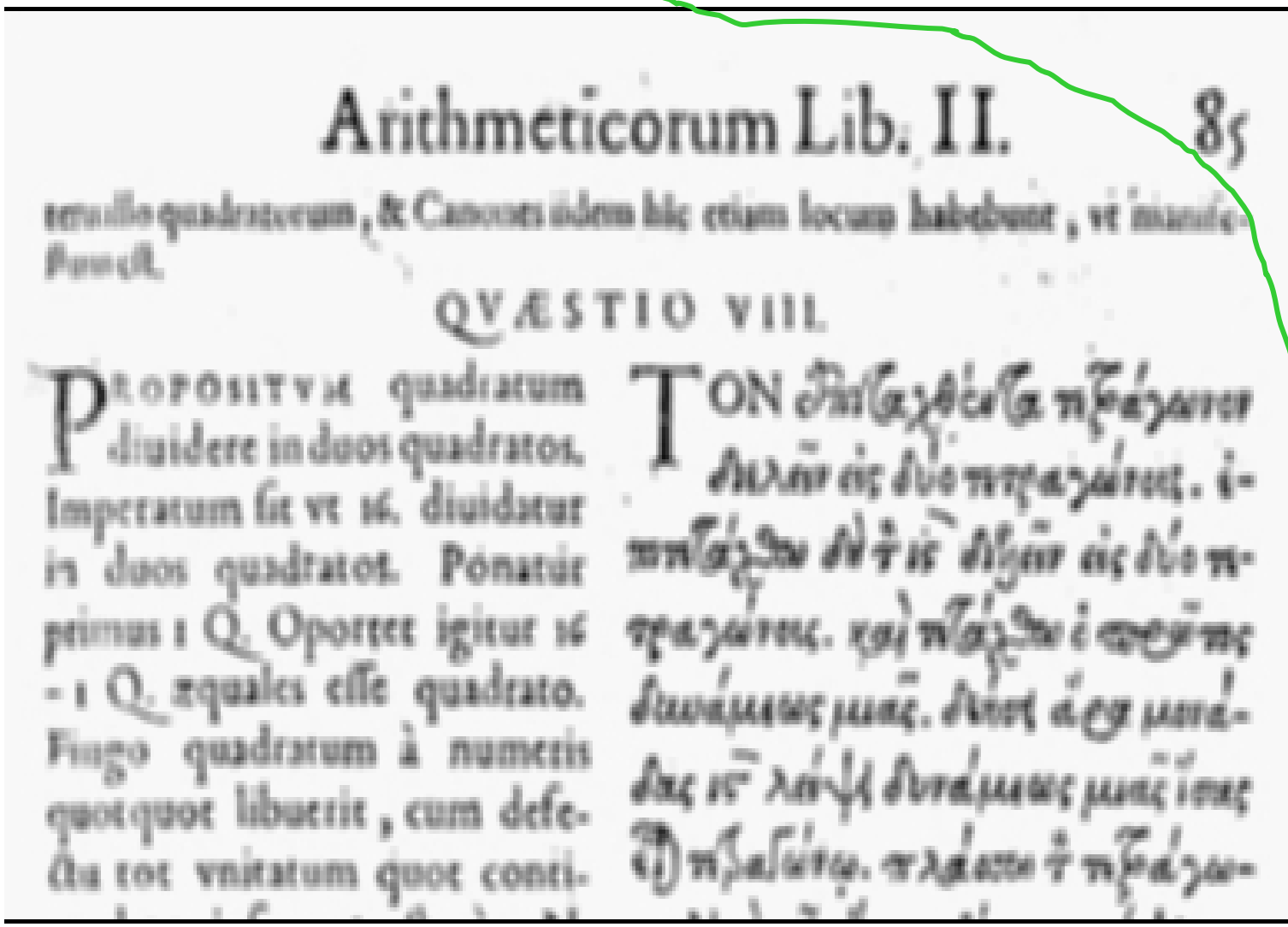
And who was she?

***Lisa*?**
M questions arose o
of the lady in the portrait
which means "the ligh
La Joconde, carries a ghts
and theories about the *Mona Lisa*'s smile. One popular theory
suggests that the lady is the Duchess of Milan, Isabella of Aragon.

Fermat's last theorem is a theorem first proposed by Fermat in the form of a note scribbled in the margin of his copy of the ancient Greek text *Arithmetica* by Diophantus. The scribbled note was discovered posthumously

Did he or didn't he?

1637



Arithmeticorum Lib. II. 85

QVÆSTIO VIII.

PROPOSITVM quadratum diuidere in duos quadratos. Imperatum sit vt 16. diuidatur in duos quadratos. Ponatur primus 1 Q. Oportet igitur 16 - 1 Q. æquales esse quadrato. Fingo quadratum à numeris quotquot libuerit, cum defectu tot vnitatum quot conti-

$$\forall n > 2 \quad x^n + y^n \neq z^n$$

Fermat's last theorem is a theorem first proposed by Fermat in the form of a note scribbled in the margin of his copy of the ancient Greek text *Arithmetica* by Diophantus. The scribbled note was discovered posthumously

Did he or didn't he? **1637**

In the words of mathematical historian Howard Eves,
"Fermat's Last Theorem has the peculiar distinction of being the mathematical problem for which the greatest number of incorrect proofs have been published."
(including Fermat's own?)

Arithmeticorum Lib. II &c

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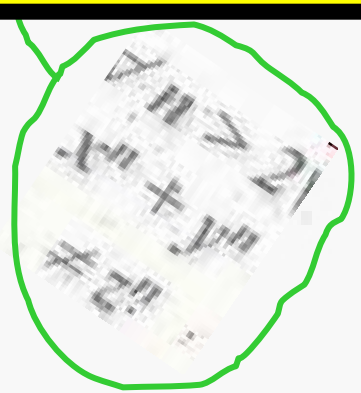

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(including Fermat's own?)

LIKE

A Short-Form *Proof* of *Fermat's Last Theorem*
www.fermatproof.com/ - CachedSimilar
Tom Ballard solves *Fermat's Last Theorem*, Puts Wiles To Shame.

БЛАЖКО ЄФФЄКТ

1907

A Z H

L K

B O

Sergei Nikolaevich Blazhko

АБВГҐДЂЃЕЀЁЄЖЗЅИЍІЇЙЈКЛЉМНЊОПРСТЋЌУЎФХЦЧЏШЩЪЫЬЭЮЯ

БЛАЖКО ЄФФЄКТ

1907

A plague for students
of Solon Bailey's "cluster-type" variable stars

L

B

Aaargh!

A mystery only pundits can love.
I spare you the details.

Sergei Nikolaevich Blazhko

АБВГҐДЂЃЕЀЁЄЖЗЅИЍІЇЙЈКЛЉМНЊОПРСТЋЌУЎФХЦЧЏШЩЪЫЬЭЮЯ

Do they or don't they?

1939

The Oosterhoff effect

van den Bergh, S. 1993, MNRAS, 262, 588.

"It is found **(with greater than 99 percent confidence)** that globular clusters of Oosterhoff class I lie on retrograde orbits more frequently than do clusters of Oosterhoff class II. A possible explanation for the observed correlation is **blah, blah, blah, ……"**

A plethora of other distinguishing oddities are known about Oosterhoff clusters.

Sidney cannot be blamed for all of them.

Do they or don't they?

1939

The Oosterhoff effect

van den Bergh, S. 1993, MNRAS, 262, 588.

"It is **than 99 percent confidence)** that glob lie on retrograde orbits m hoff class II. A pos **blah,**

A plethora of other dist about Oosterhoff

Sidney cannot be blamed for all of them.

This conclusion was reaffirmed by

LEE & CARNEY, 1999, AJ, 118, 1373
RR LYRAE LUMINOSITY DIFFERENCES BETWEEN OOSTERHOFF GROUP I AND II CLUSTER SYSTEMS AND THE ORIGIN OF THE OOSTERHOFF DICHOTOMY

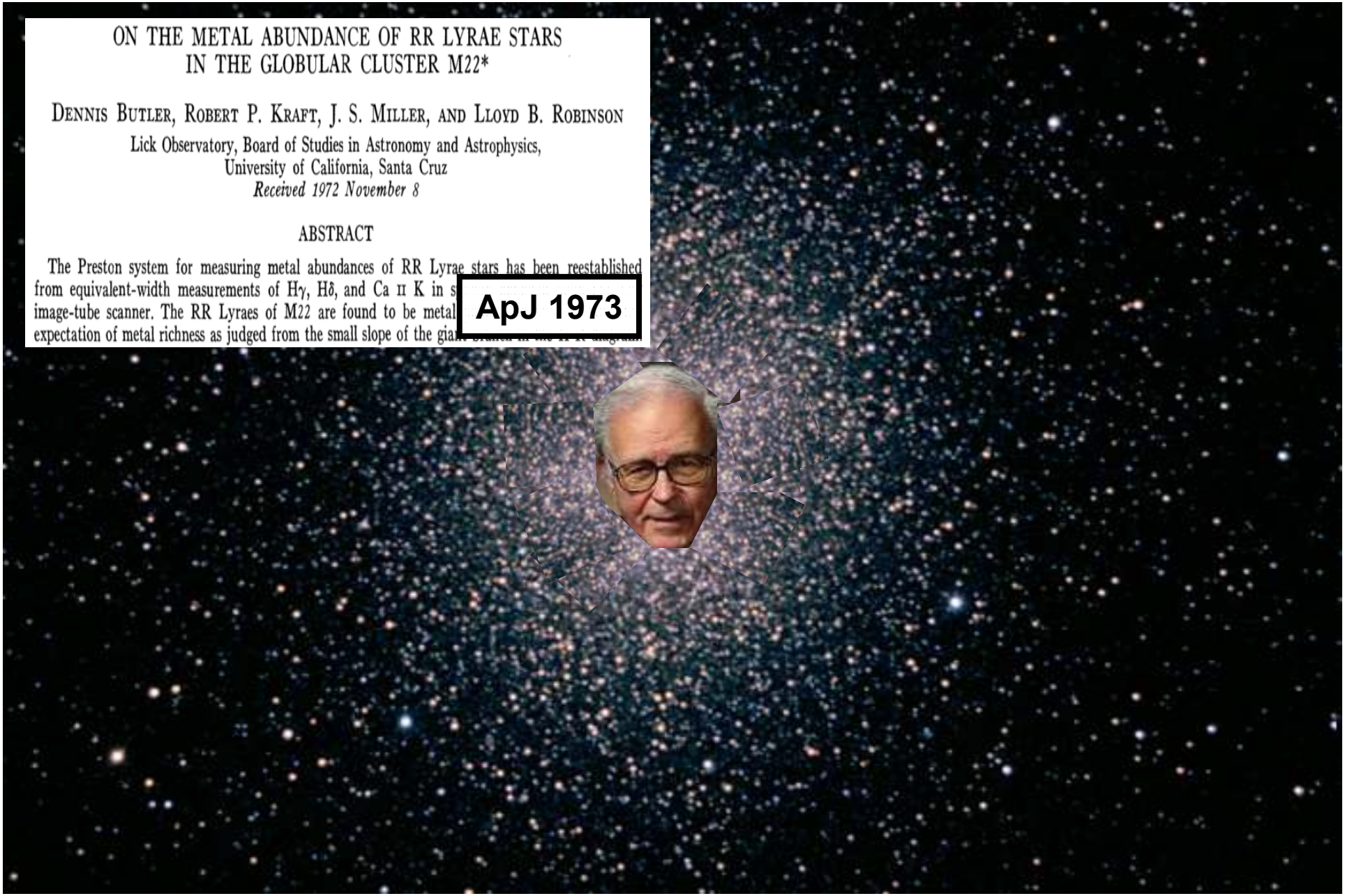
but it has not attracted much attention.

Finally,
we come to
Bob
Himself

Bob has been near the center of globular cluster research ...

… for a long time

1973



ON THE METAL ABUNDANCE OF RR LYRAE STARS IN THE GLOBULAR CLUSTER M22*

DENNIS BUTLER, ROBERT P. KRAFT, J. S. MILLER, AND LLOYD B. ROBINSON
Lick Observatory, Board of Studies in Astronomy and Astrophysics,
University of California, Santa Cruz
Received 1972 November 8

ABSTRACT

The Preston system for measuring metal abundances of RR Lyrae stars has been reestablished from equivalent-width measurements of Hγ, Hδ, and Ca II K in s
image-tube scanner. The RR Lyraes of M22 are found to be metal
expectation of metal richness as judged from the small slope of the gia

ApJ 1973

… for a long time

1973

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ApJ 1973

GCs are his current targets after fifty distinguished years of:

Cepheids and RR Lyrae stars: atmospheres, ρu^3, etc

CV/Novae/Binary phenomena

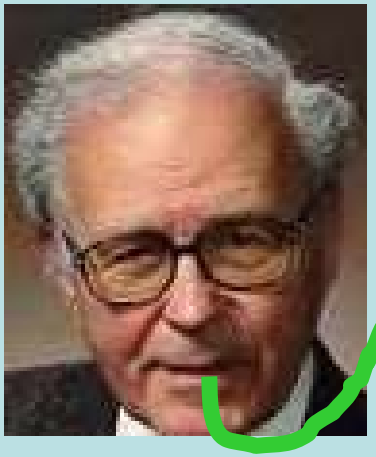
- **gravitational radiation**
- **mass transfer**

Main Sequence Rotation

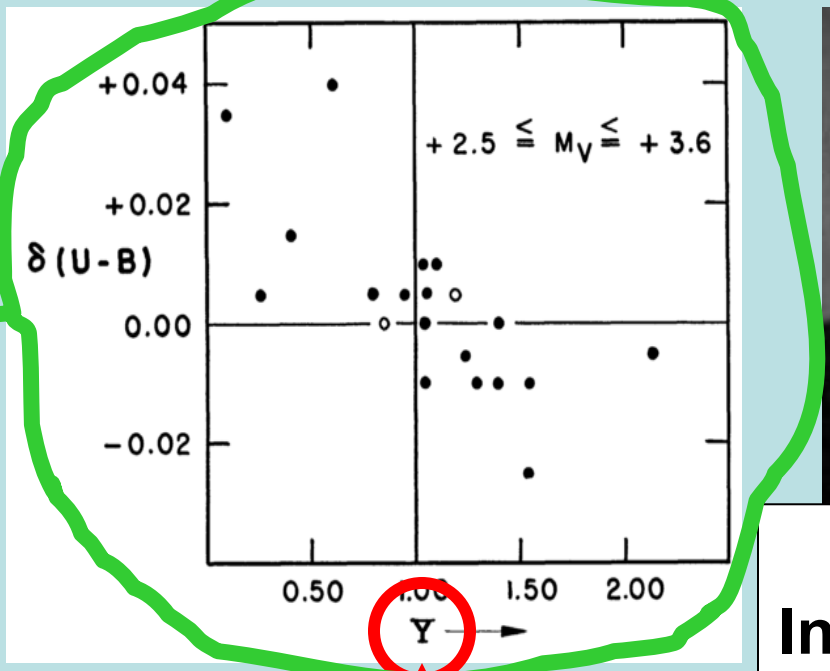
And on and on and on …

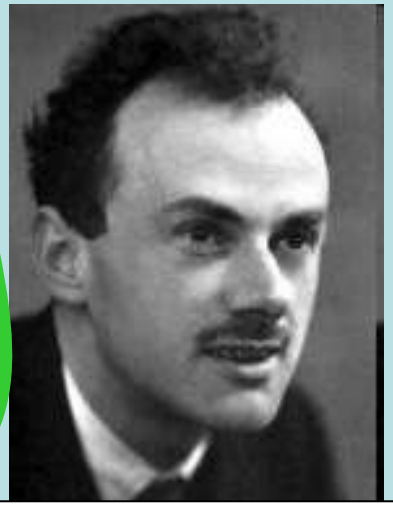
More later

Another aside: Bob was talking about effects of stellar rotation at an IAU symposium somewhere in Europe.



speaking
at the podium





sitting
In the audience

Y is some godawful stellar rotation parameter

GCs
Cep
CV/
g
mass transfer
Main Sequence Rotation
And on and on.

1965

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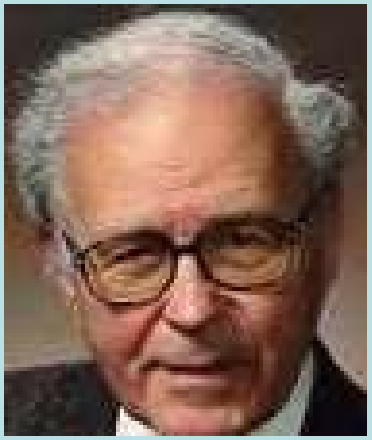

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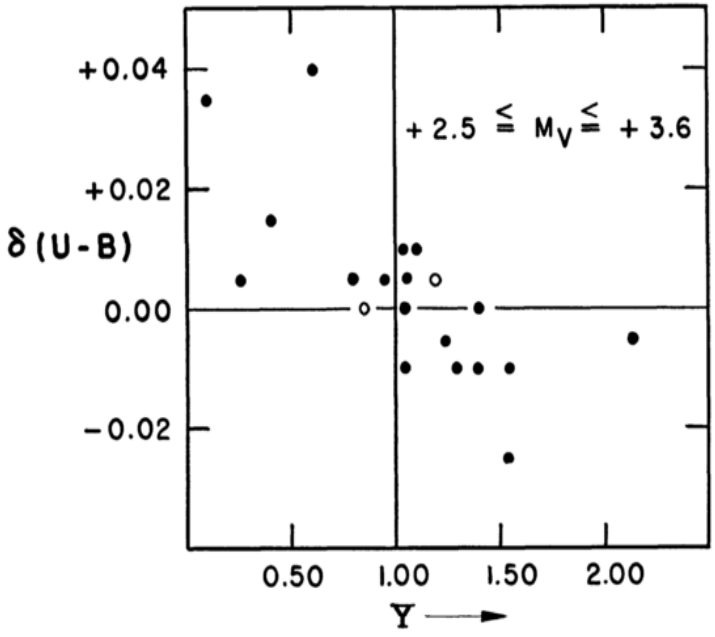

sitting
In the audience

Overheard afterwards in the audience:

"All I wanted to know is what is the mean angular momentum density in the Galaxy!"

GCs
Cep
CV/
g
mass transfer
Main Sequence Rotation
And on and on.

1965

… for a long time

1975

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ApJ 1973

05.05.04 Carbon and Nitrogen Abundances in the Atmospheres of Subgiant and Asymptotic Giant Branch Stars in M92. DENNIS BUTLER*, DUANE CARBON and ROBERT P. KRAFT, Lick Obs., Bd. of Studies in Ast. and Ap., U. of Calif., Santa Cruz. - Using the Wampler-Robinson Image Tube Scanner operated at the Cassegrain focus of the 120-inch telescope, we have observed a sample of subgiant (SG) and asymptotic giant branch (AGB) stars in M92, in the wavelength interval λλ3100 Å - 5100 Å, with resolution ~
of 28 stars is confined largely to th

BAAS 1975

… for a long time

1975

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BAAS 1975

characteristically playing second fiddle, so that youngsters could get their names up in lights

… for a long time

1975

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BAAS 1975

while he assembled his overview

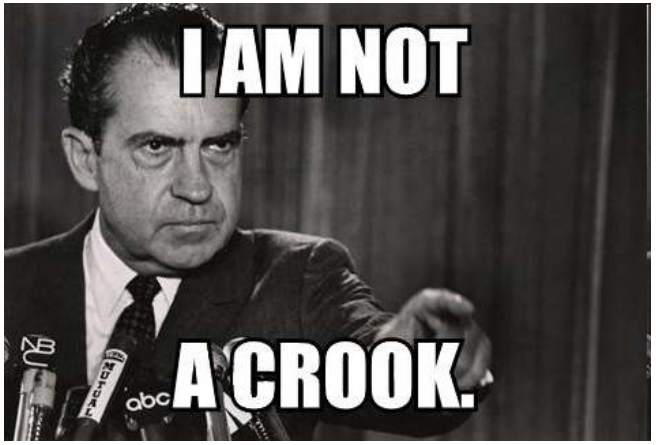
ON THE NONHOMOGENEITY OF METAL ABUNDANCES IN STARS OF GLOBULAR CLUSTERS AND SATELLITE SUBSYSTEMS OF THE GALAXY

Robert P. Kraft
Lick Observatory, Board of Studies i…
University of California, Santa Cruz, …

ARA&A 1979

While we recall all
of his admirable traits,
we must also acknowledge
that

Bob has a severe Watergate problem.



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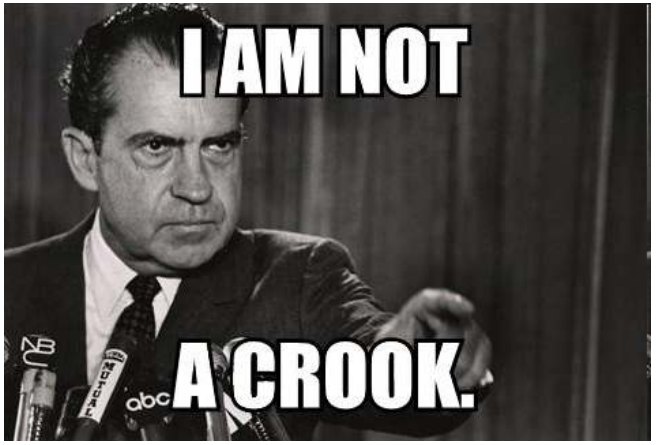
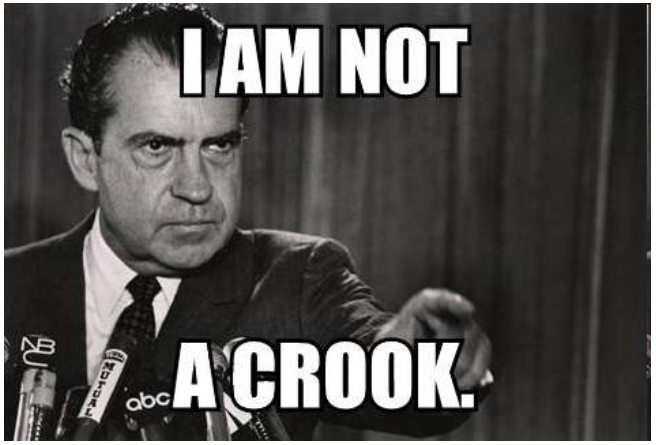


It is an issue that has bedevilled our honoree for decades,

Bob has a severe Watergate problem



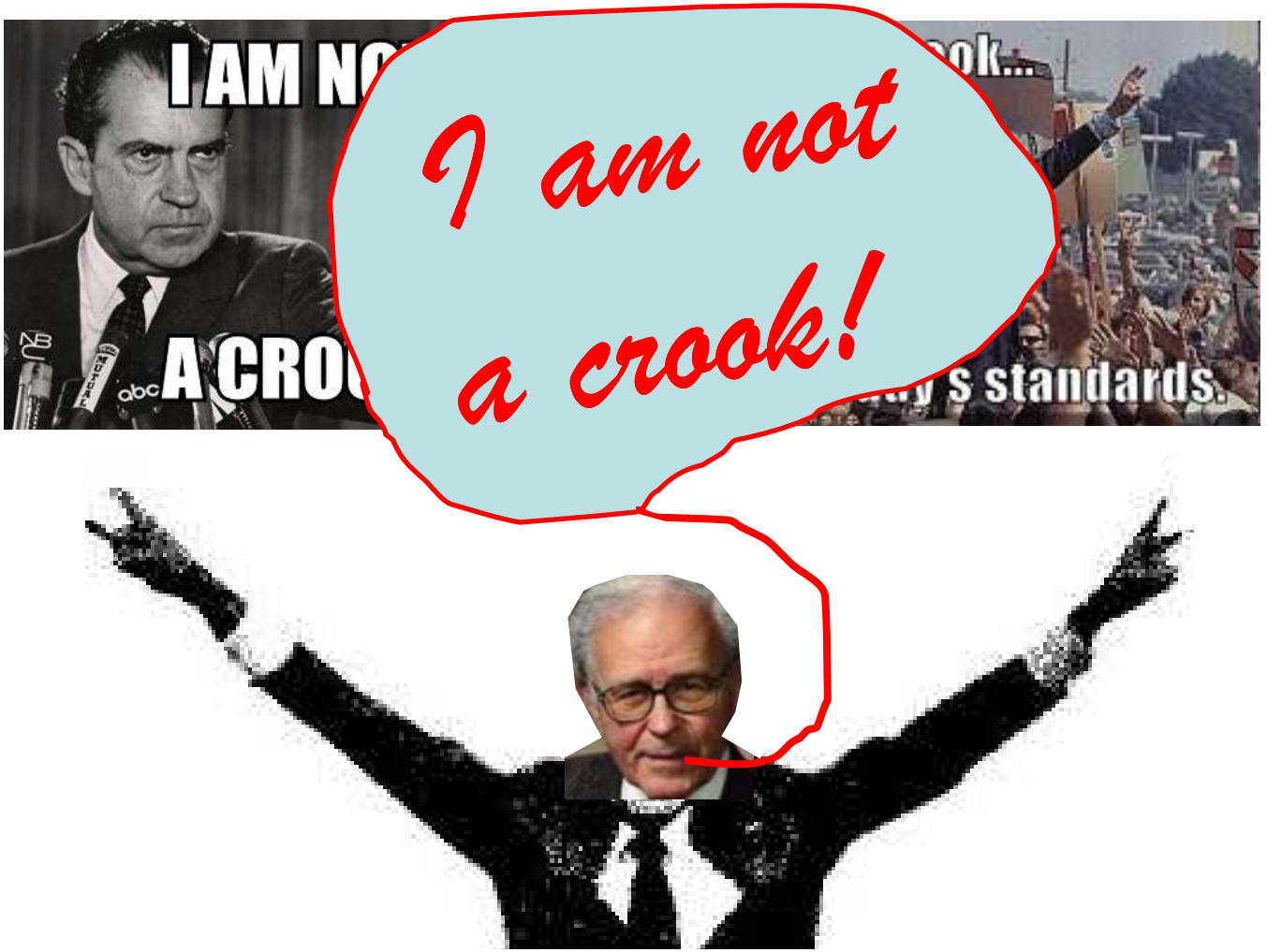
It is an issue that has bedevilled our honoree for decades, giving rise to sporadic, sometimes uncontrollable outbursts like this

RPK's bête noir

1972

Growls accompanied by shaking of jowls

RPK, impersonator *nonpareil*



I was not present, but Steve Shectman tells me that Bob, while President of the AAS, lost control of himself in this manner for some time during an after-dinner speech. Questioned later, Bob could not recall the episode for 18 minutes.

However, his passion is a redeeming virtue

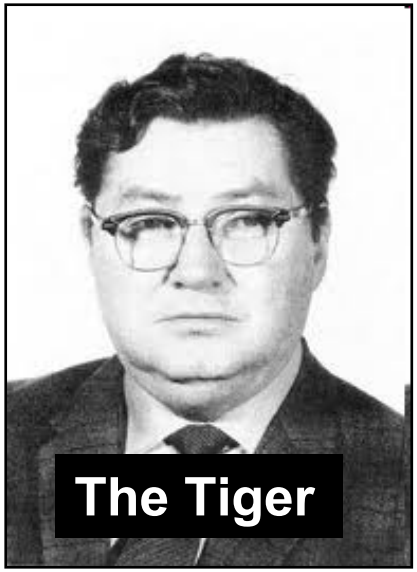
Whenever I think of Bob,
this pose reminds me of his passions,
particularly in all matters of social justice,

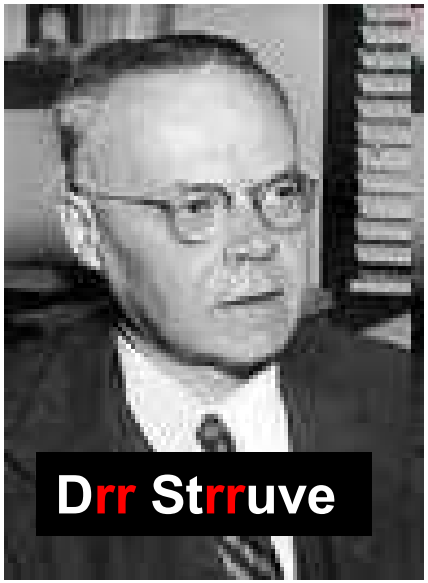
However, his passion is a redeeming virtue

Whenever I think of Bob,
this pose reminds me of his passions,
particularly in all matters of social justice,
and particularly after a bottle of fine wine!

A few shared experiences from the distant past

Berkeley Astronomy 1955





Mr. Preston.. feel in your bones? Mr Kraft please stand up ..

Chicago Tribune

ASSASSIN KILLS KENNEDY

LYNDON JOHNSON SWORN IN

GOVERNOR OF TEXAS WOUNDED; MARXIST ACCUSED OF MURDER

LO 1963
Hα
Microphotometer room

Wasiutinski and all that …

What really impressed Bob was

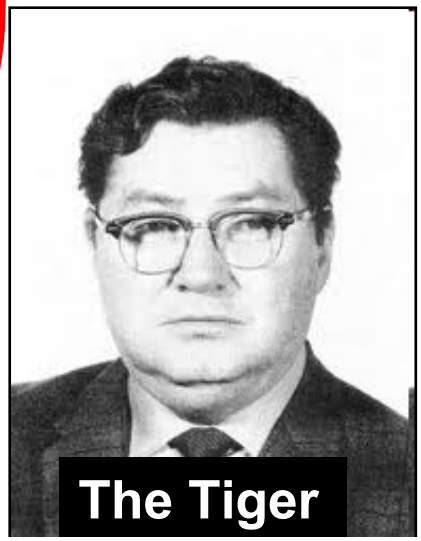
$$\rho u^3$$

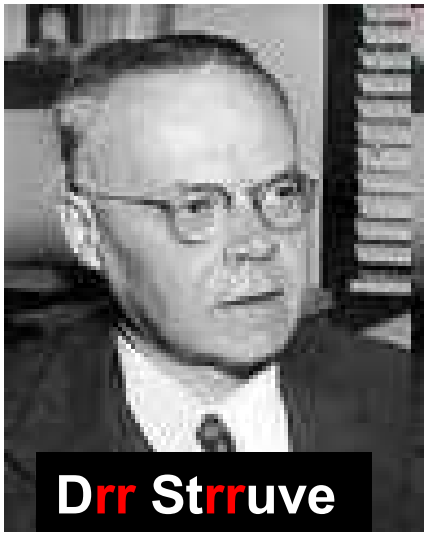
He would use it every time the topic of cool stellar atmospheres came up.

UCSC 1967±
NSF Proposal
(The recently transplanted LO staff wasn't quite up to running a distinguished academic program on the Santa Cruz campus)

A few shared experiences from the distant past

Berkeley Astronomy 1955


The Tiger


Drr Strruve

What a friendly department!

Mr. Preston.. feel in your bones? Mr Kraft please stand ...

~~1963~~
~~Hα~~
~~Microphotometer~~
~~room~~

~~Wasiutinski and all that ...~~

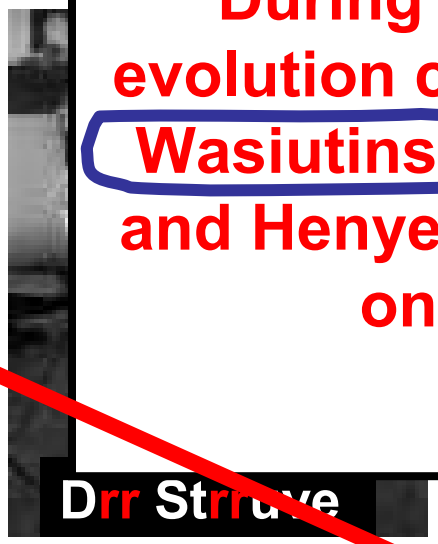
~~What really impressed Rao was~~

~~He would use it every time the topic of cool stellar atmospheres came up.~~

~~UCSC 1967±~~
~~NSF Proposal~~
~~(The recently ... LO staff wasn't ... running a distinguished academic program on the Santa Cruz campus)~~

A few shared experiences from the distant past

Berkeley Astro



What a friendly department!

Mr. Preston.. feel in your bones? Mr Kraft please stand up ..

During construction of his stellar evolution code Henyey relied heavily on Wasiutinski's treatment of convection, and Henyey's esteem for JW rubbed off on all of his students …

Wasiutinski and all that …

What really impressed Bob was

$$\rho u^3$$

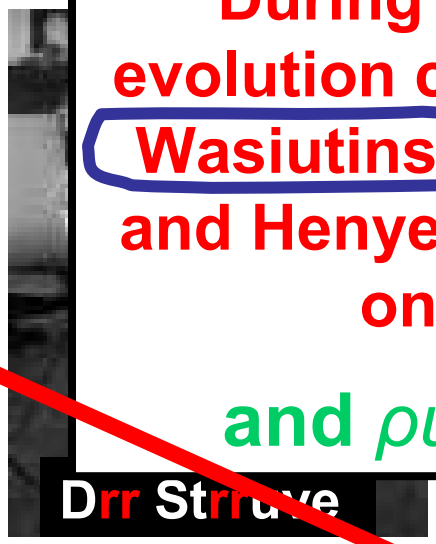
He would use it every time the topic of cool stellar atmospheres came up.

Jeremi Wasiutynski

Norske Videnskapsakademie 1946

A few shared experiences from the distant past

Berkeley Astro



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Mr. Preston.. feel in your bones? Mr Kraft please stand up ..

During construction of his stellar evolution code Henyey relied heavily on Wasiutinski's treatment of convection, and Henyey's esteem for JW rubbed off on all of his students …

and ρu^3 stuck in Bob's head

Wasiutinski and all that …

What really impressed Bob was

$$\rho u^3$$

He would use it every time the topic of cool stellar atmospheres came up.

Jeremi Wasiutynski

Norske Videnskapsakademie 1946

A few shared experiences from the distant past

A sad day at Lick Observatory in 1963

Hα

In the Microphotometer Room
Our work came to an abrupt end.

Chicago Tribune

ASSASSIN KILLS KENNEDY

LYNDON JOHNSON SWORN IN

GOVERNOR OF TEXAS WOUNDED; MARXIST ACCUSED OF MURDER

New President Picks Up Reins

THE WIDTH OF Hα AS A DISCRIMINANT OF LUMINOSITY IN THE SPECTRA OF LATE-TYPE STARS*

ROBERT P. KRAFT
Mount Wilson and Palomar Observatories
Carnegie Institution of Washington, California Institute of Technology

GEORGE W. PRESTON
Lick Observatory, University of California, Mount Hamilton, California

AND

SIDNEY CARNE WOLFF
Berkeley Astronomical Department, University of California, Berkeley, California

Received February 17, 1964

An Astronomical Life Salted by Pure Chance

Kraft, Robert P. 2009ARA&A..47, 1

Both of us having graduated from the Berkeley Ph.D. program, Preston and I were great admirers of Otto Struve and of the "Yerkes Observatory style," in which an observatory-based graduate program included a cadre of theorists to complement the observers. Although Lick had appointed Bodenheimer, a theoretician in the field of stellar structure and evolution, to the mountain-top staff shortly before the move to UCSC, we saw the need for theoretical expertise in a number of other areas. At the time, the NSF was offering a group of "Science Departmental Improvement" grants, and with Whitford's approval Preston and I wrote a proposal for such a grant to Lick/UCSC in the amount of $600 K. Following a site visit involving the NSF astronomy program director and an evaluation committee, the funds were secured for a five-year program

UCSC 1967±

NSF Proposal

(The recently transplanted LO staff wasn't quite up to running a complete academic program on the Santa Cruz campus)

In conclusion: Berkeley 1955

Sunday afternoons
in Albany student village:
4-finger Mozart

In conclusion: Berkeley 1955

Sunday afternoons in Albany student village: 4-finger Mozart

The Prestons watched tearfully as the Krafts departed to Pasadena.