

Stellar Age Chronometers

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Sunday, 27 June 2021

Abstract

Scientists use various methods to determine the age of stars such as radiometric, nuclear and spin down ages. These produce many ages that are impossible. Some have future ages showing the star does not exist in the present but in the future. Many give ages well more than the assumed 13.8-billion-year evolutionary age of the universe. There are many conflicting dates for the one star.

Introduction

A fifty-page article recently points that there is only one star whose age is accurately known: “There is exactly one stellar age that is both precise and accurate, that of the Sun, and it illustrates some of the inherent problems in determining ages. The Sun is $4,567 \pm 5$ million years old. The extraordinary precision of 1 million years represents measurement error (individual measurements are precise to 0.6 million years, 2002), and the only slightly larger systematic error of 5 million years is due to uncertainty over the precise sequence of events in the early years of the Solar System’s history. That systematic error should lessen as we understand those events better. This age is determined from the decay of radionuclides.” (Soderblom, 2010, P. 586)

This date is determined by radiometric dating which has been shown by creationists to have many inherent problems. According to the Big Bang theory the age of the Universe is 10 to 13.75 billion years. Standard evolutionist publications give the age of the universe as 13.75 billion years. **(Wikipedia)**

Thorium and Uranium Chronometers

Research done in 2002 (**Schatz, 2002**) on the star CS 31082-001 has produced an array of dates [Table 1] between 300 million and 34 billion years old. Schatz claims that the stars age can be determined accurately: “Stellar elemental abundance observations of long-lived radioactive nuclear species synthesized in the r-process can be used to derive estimates for the ages and history of the underlying nucleosynthesis events.” (**Schatz, 2002, P. 626**) In another place he admits dates have appeared far older than the Big Bang: “The resulting age range for the r-process elements in CS 31082-001 is 9–18 Gyr.” (**Schatz, 2002, P. 627**) Another problem are negative or future ages (**Schatz, 2002, P. 635**) which are impossibly young. Dates as low as -8 billion years and -5.1 billion years have been obtained.

Table 1

Dating	Evolution	Mass	Age	Error	Max Age	Min Age
Method	Model	Model	(Ga)	(Ga)	(Ga)	(Ga)
U/Th	Single	EFT	3.2	2.3	5.5	0.9
U	Single	EFT	2.3	1.8	4.1	0.5
Th	Single	EFT	0.3	5.7	6	-5.4
U/Th	Uniform	EFT	7.3	6.3	13.6	1
U	Uniform	EFT	5	4.2	9.2	0.8
Th	Uniform	EFT	1	11	12	-10
U/Th	Single	HFB	0.3	2.3	2.6	-2
U	Single	HFB	4.9	1.8	6.7	3.1
Th	Single	HFB	14.8	5.7	20.5	9.1
U/Th	Uniform	HFB	0.8	4.7	5.5	-3.9
U	Uniform	HFB	11	4.9	15.9	6.1
Th	Uniform	HFB	34	16	50	18
		Max Age	34	16	50	18
		Min Age	0.3	1.8	2.6	-10

(Schatz, 2002, P. 632)

Table 1 contains four negative dates [Red] and seven dates [Blue] older than the Big Bang [14 billion Years] explosion. There is a 60 billion age range between the smallest and oldest dates.

The author uses various unproved ‘assumptions’ to obtain dates. The author uses the word assumption over 20 times. “While all our r-process models pass this important test, the large spread of the single-event ages from the HFBCS-1 calculations is a problem. Of course, we do not necessarily expect consistent single-event ages, as the entire history of Galactic chemical evolution is surely not characterized by a single burst of elemental enrichment.” (**Schatz, 2002, P. 632**) There are three age graphs (**Schatz, 2002, P. 635, 636**) in Schatz’s article. If we put them into Microsoft Paint we can use the pixel coordinates to work out the values of the data points.

Table 2

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	7.33	-10.12	17.44
2	8.55	-6.10	14.65
3	7.85	-8.72	16.57
4	9.59	-2.97	12.56
5	8.55	-6.45	15.00
6	8.90	-5.41	14.30
7	8.90	-4.71	13.60
8	9.07	-18.49	27.56
9	4.71	-5.93	10.64
10	8.72	1.05	7.67
11	10.81	-6.80	17.62
12	8.20	8.72	0.52
13	13.43	12.03	1.40
14	14.65	-0.35	15.00
Average	9.23	-3.87	13.18
Maximum	14.65	12.03	27.56
Minimum	4.71	-18.49	0.52
Difference	9.94	30.52	27.03

(Schatz, 2002, P. 635)

Table 2 contains eleven negative dates [Red] and one date older [Blue] than the Big Bang [14 billion Years] explosion. There is a 33 billion age range between the smallest and oldest dates.

Table 3

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	13.48	15.00	1.52
2	11.04	7.68	3.35
3	11.65	9.51	2.13
4	11.34	7.68	3.66
5	11.65	9.21	2.44
6	11.04	6.77	4.27
7	11.34	8.29	3.05
8	10.43	4.94	5.49
9	11.04	7.07	3.96
10	12.56	11.95	0.61
11	11.65	9.21	2.44
12	13.17	13.78	0.61
13	12.26	10.43	1.83
14	15.91	22.32	6.40
15	13.17	13.78	0.61
16	14.39	17.44	3.05
17	12.56	12.26	0.30
18	12.87	12.87	0.00
Average	12.31	11.12	2.54
Maximum	15.91	22.32	6.40
Minimum	10.43	4.94	0.00
Difference	5.49	17.38	6.40

(Schatz, 2002, P. 636)

Table 3 contains six dates older than the Big Bang explosion and a seventeen-billion-year age range. “However, the resulting U/X (weighted average 7:6 +/- 2:3 Ga), Th/X (weighted average -8:1 +/- 5:8 Ga), and U/Th (15:5 +/- 3:2 Ga) ages clearly do not agree with one another.” (Schatz, 2002, P. 634)

Table 4

Sample	Uranium Age (Ga)	Thorium Age (Ga)	Difference
1	13.19	8.55	4.64
2	14.64	12.75	1.88
3	13.77	10.00	3.77
4	15.65	15.65	0.00
5	14.20	11.88	2.32
6	14.93	13.48	1.45
7	14.78	13.91	0.87
8	10.72	0.14	10.58
9	14.78	12.75	2.03
10	16.96	19.86	2.90
11	14.35	12.03	2.32
12	19.13	27.25	8.12
13	20.58	30.58	10.00
14	16.38	18.70	2.32
15	15.51	15.36	0.14
Average	15.30	14.86	0.44
Maximum	20.58	30.58	10.58
Minimum	10.72	0.14	0
Difference	9.86	30.72	10.58

(Schatz, 2002, P. 636)

Table 4 contains eighteen dates older than the Big Bang explosion and an age range of 30 billion years.

Assumptions/Problems

- 1
- Although presently ad hoc, this “actinide boost” assumption solves the apparent problem of the relative age difference compared with other metal-poor halo stars and, at the same time, the problem of the inconsistency of ages based on U/(stable nucleus), Th/(stable nucleus) and U/Th ratios.
- 2
- An important assumption underlying all Th cosmo-chronometry applications is that all r-process events produce the same relative abundance pattern among the heavier species, especially the same ratio of Th to a stable rare earth reference element, often taken to be Eu.
- 3
- In contrast to the multievent canonical r-process model, the additional assumption of a smooth behaviour of temperature and neutron density in the r-process reduces the number of free parameters considerably.
- 4
- If one assumes a solar zero-age abundance distribution, then the consistency requirement for the Th/X, U/X, and U/Th ages can be used to test and constrain the r-process model used.
- 5
- The calculations are performed within the waiting-point approximation, assuming complete (n,)–(, n) equilibrium within an isotopic chain.
- 6
- A single r-process component is calculated assuming irradiation of an Fe seed, with constant neutron number density n and constant temperature T, for a time.
- 7
- The r-process abundances are then calculated as a superposition of many components, assuming a power-law distribution of the component weights, and irradiation timescales, as a function of neutron density.
- 8
- We display the abundances after -delayed fission and neutron emission, but before -decay, to illustrate the impact of different nuclear structure assumptions along the r-process paths.
- 9
- We assume that fission is always faster than neutron emission.
- 10

For example, the assumption of a single r-process event provides a model-independent lower limit for the age of the pre-solar nebula.

As an example, Table lists the ages obtained under the assumption of a uniform r-process production, which shows indeed a strongly increased inconsistency for the HFBCS-1 ages.

Estimates are based on the r-process model predictions with two mass models and with two simple assumptions on Galactic chemical evolution.

This shows that our choice of r-process model parameters, based on a smooth extrapolation from the solar abundance pattern into the actinide region and reproducing the currently predicted solar Pb r-process abundance, is not appropriate for predicting the zero-age U and Th abundances in CS 31082-001 (assuming that a single r-process event, or r-process events with time intervals that are small compared to the total age, is responsible for the r-process enrichment of CS 31082-001).

It is not unreasonable to assume that the prediction of the U/Th ratio produced in the r-process is sufficiently robust to be still applicable to CS 31082-001. The main argument for this assumption is the fact that both elements are synthesized from the decay of a large number of progenitor nuclei synthesized by the r-process in the same region of the chart of nuclides. With our r-process model, this assumption would yield an age estimate for the r-process elements in CS 31082-001 of 15 3:2 Gyr.

The only possibility of resolving these problems, while still upholding the principle of a universal r-process pattern, would be to assume that the derived very small Th/X ages are correct, but that the r-process elements in CS 31082-001 were implanted long after the formation of the star.

Indeed, Qian & Wasserburg speculate that the large enrichment of heavy r-process elements in CS 31082-001 can only be explained by exposure of the star to a nearby r-process event, for example, the supernova explosion of a companion star.

We can estimate a lower limit of the expected lead abundance in our proposed scenario by assuming that the U and Th enrichment is due to an enhancement of abundances in the A = 232-253 region (before -decay) only.

However, it is significantly narrower than the range of predictions given in Goriely & Clerbaux for calculations with different nuclear physics assumptions (0.22 to +0.05).

Clearly, an identification of the r-process site and more realistic r-process models would also be important to verify the assumptions underlying the classical r-process model.

If we assume that this enhancement does not affect the U/Th ratio produced in the r-process, we find an age of 15.5 Gyr for the r-process elements in CS 31082-001.

While all our r-process models pass this important test, the large spread of the single-event ages from the HFBCS-1 calculations is a problem.

It is perhaps suggestive that both problems can be remedied by the proposed initial U and Th enhancement.

Dating of the Strongly r-process Enhanced Stars

Another star dated has an age range of 43.8 billion years. “Radioactive dating for CS 29491–069 with the observed thorium and rare-earth element abundance pairs results in an average age of 9.5 Gyr, when based on solar r-process residuals, and 17.6 Gyr, when using HEW model predictions. Chronometry seems to fail in the case of HE 1219–0312, resulting in a negative age due to its high thorium abundance.” (Hayek, 2009, Page 511)

Fourteen dates are negative. Eleven dates are over 16 billion years old. CS 29491-069 has an age range of 43.8 billion years (-7.3 to 36.5 billion years old).

Isotope	CS 29491-069	CS 29491-069	Age	HE 1219-0312	HE 1219-0312	Age
Ratios	Residual Age	HEW Age	Difference	Residual Age	HEW Age	Difference
Th/Ba	1.9	17.1	15.2	-6.5	8.7	15.2
Th/La	0.9	16.5	15.6	-5.7	9.9	15.6
Th/Ce	17.1	24.6	7.5	-0.6	6.8	7.4
Th/Pr	10.3	13.2	2.9	-6.5	-3.6	2.9
Th/Nd	10.5	13.4	2.9	-2.6	0.4	3
Th/Sm	12	11.8	-0.2	-0.1	-0.3	0.2
Th/Eu	3	3.8	0.8	-4.9	-4.1	0.8
Th/Gd	13.5	21.1	7.6	-0.5	7.1	7.6
Th/Dy	14	24.2	10.2	1.8	12	10.2
Th/Ho	4.4	21.2	16.8	-7.3	9.5	16.8
Th/Er	16.8	26.4	9.6	1.8	11.5	9.7
Th/Tm				0	0.1	0.1
Th/Hf				-2.1	24.2	26.3
Th/Os	36.5	24.6	13.9			
Maximum	36.5	26.4	16.2	1.8	24.2	26.3
Minimum	0.9	3.8	-0.2	-7.3	-4.1	0.2
Difference	34.6	22.6	16	9.1	28.3	26.1

(Hayek, 2009, Page 522)

Assumptions/Problems

We also compare the observed pattern with recent high-entropy wind (HEW) calculations, which assume core-collapse supernovae of massive stars as the astrophysical environment for the r-process, and find good agreement for most lanthanides.

The MARCS models assume 1D plane-parallel stratification or spherical symmetry, depending on the surface gravity, as well as hydrostatic equilibrium and radiative transfer in local thermodynamic equilibrium (LTE), also including continuum scattering.

Energy conservation is fulfilled by assuming flux constancy for radiative and convective transport.

Convergence is typically achieved after a few iterations when the number of data points assumed as true continuum remains constant.

Assuming the correction of +0.4 dex for Mn I adopted by Cayrel leads to very good agreement between the Mn I and Mn II abundances.

The contributions to the total uncertainty, were then combined as the sum of squares, assuming their complete independence.

Assuming an incomplete ejection or fallback scenario, more than 80 % of the synthesized Sr, Y and Zr nuclei failed to reach the ISM in both cases.

The estimate for hafnium is bracketed for the HEW model due to problems with the nuclear data, rendering the synthetic yield unreliable. It is clear that the high Th abundance causes this shift towards low or even negative ages, and the significantly different results for the two stars, which were obtained using the same initial abundance ratios.

The Metal-Poor Halo Star Bd+173248

This star was analysed in 2002 and found to contain osmium, platinum, and (for the first time in a metal-poor star) gold, elements whose abundances can only be reliably determined using HST. **(Cowan, 2002, Page 861)** Five dates older than the Big Bang were obtained.

Table 6		
Dating	Age	Lower
Method	(Ga)	Limit
Th/Eu	10	8.2
Th/Ir	21.7	14.8
Th/Pt	10.3	16.8
Th/U	13.4	11
U/Ir	15.5	13.5
U/Pt	12.4	14.6

(Cowan, 2002, Page 876)

There seems to be an endless set of unprovable assumptions in all calculations. “We caution, however, that all of these age estimates are very sensitive to uncertainties both in the theoretically predicted initial values and in the observations themselves; this is particularly true for our very weak detection of uranium. In addition, further investigation of any possible real offset between the rare earth elements and the third r-process peak elements and the corresponding effect on nucleo cosmo chronometry will be necessary.” **(Cowan, 2002, Page 876)**

Assumptions/Problems

1
Furthermore, metallicity will be assumed here to be equivalent to the stellar [Fe/H] value.
2
Remembering these caveats, adopting Fe/H = 2.1 in the T eff calculations, and (for the moment) assuming no interstellar reddening, the observed V-K = 2.06 yields T eff; 4985 and 5025 K.
3
These values and an assumption of T eff = 5200 K leads to log 1.8, in excellent agreement with the spectroscopic value.
4
If we instead assume a temperature at the high end of the estimates, T eff = 5600 K.
5
The primary N abundance indicator is NH, since the CN absorption even at the 0–0 band head at 3883 Å is no more than 10% of the continuum, and the N abundance derived from CN depends directly on the assumed abundance of C.
6
To account for a few absorptions in the spectra that have no obvious atomic and molecular identification, we arbitrarily assumed that they were Fe i lines with EP = 3.5 eV.
7
Therefore, for an individual synthesis we varied the absorptions of a given molecule as a set by simply varying the assumed abundance of C, N, or O.
8
The [X/Fe] ratios were computed by assuming that Fe/H = -2.09 and adopting the recommended solar abundances log of Grevesse & Sauval.

Uranium-Thorium Cosmo Chronology

There is an endless list of unprovable assumptions in the article.

1. “In this model, the proto–neutron star mass and the (asymptotic) neutrino sphere radius are assumed to be 2.0M_o and 10 km, respectively.” **(Wanajo, 2002, Page 853)**
2. “The temperature and density histories of the material involved in the neutron capture processes are obtained with the assumption of a steady flow of the neutrino-powered winds, with general relativistic effects taken into account.” **(Wanajo, 2002, Page 853)**
3. “The mass-integrated r-process yields, obtained by assuming a simple time evolution of the neutrino luminosity, are compared to the available spectroscopic elemental abundance data of CS 31082-001.” **(Wanajo, 2002, Page 853)**
4. “In fact, the large dispersion of Eu/Fe observed in halo stars (more than 2 orders of magnitude) has been naturally explained by chemical evolution models that make such assumptions.” **(Wanajo, 2002, Page 854)**
5. “Thus far, the initial production of Th/r has been determined by fitting theoretical nucleosynthesis results to the solar r-process pattern, with the assumption that the r-pattern was universal in all astrophysical environments.” **(Wanajo, 2002, Page 854)**
6. “Therefore, any age estimates that demand assumption of the universality of the r-process pattern may in fact be unreliable.” **(Wanajo, 2002, Page 854)**
7. “In addition to the above nonuniversality problem, the initial r-process pattern has thus far been determined theoretically by the superposition of nucleosynthesis results, where one is forced to assume constant temperatures, neutron number densities, and exposure times.” **(Wanajo, 2002, Page 854)**
8. “These approximations have been necessary because of the lack of a reliable astrophysical model for the r-process site.” **(Wanajo, 2002, Page 854)**
9. “The system is treated as time stationary and spherically symmetric, and the radius of the neutron star is assumed to be the same as that of the neutrino sphere.” **(Wanajo, 2002, Page 855)**
10. “The neutrino luminosities, L, of all neutrino flavors are assumed to be equal.” **(Wanajo, 2002, Page 855)**
11. “This assumption may be inadequate, as the physical conditions of the neutrino sphere and the outer boundary are not necessarily causally connected.” **(Wanajo, 2002, Page 855)**

Table 7							
Method	Th/Eu	Th/Os	Th/Ir	U/Eu	U/Os	U/Ir	U/Th
Age	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)
	18.77	57.52	27.18	15.63	27.95	18.3	14.16
	12.61	46.73	16.09	13.62	24.47	14.73	14.1
	5.17	34.01	3.64	11.32	20.49	10.83	14.19
	-16.9	11.67	-17.55	3.97	13.05	3.76	13.7
	-32.54	-0.84	-29.64	-1.12	8.96	-0.2	13.53
	-118.21	-51.05	-76.97	-29.3	-7.94	-16.18	12.16
Average	-21.85	16.34	-12.875	2.35	14.50	5.21	13.64
Maximum	18.77	57.52	27.18	15.63	27.95	18.3	14.19
Minimum	-118.21	-51.05	-76.97	-29.3	-7.94	-16.18	12.16
Difference	136.98	108.57	104.15	44.93	35.89	34.48	2.03

Table 7 contains 14 negative dates [red] and 15 dates [blue] older than the Big Bang explosion and a 175-billion-year age range. **(Wanajo, 2002, Page 863)** The data in table 8 is calculated from the age graph **(Wanajo, 2002, Page 863)** by the same author.

Table 8

Method	Th/Eu	Th/Os	Th/Ir	U/Eu	U/Os	U/Ir	U/Th
Age	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)	(Ga)
	-32.31	-1.23	-29.85	-29.23	-8.00	-16.31	13.54
	-16.62	11.38	-17.23	-0.92	8.62	0.31	13.54
	5.23	33.85	3.69	4.00	12.92	4.31	13.54
	12.31	46.46	16.00	12.00	20.62	11.08	13.54
	18.77	57.54	27.38	13.85	24.00	15.08	13.54
				16.31	27.69	18.46	13.54
Average	-2.52	29.60	0.00	2.67	14.31	5.49	13.54
Maximum	18.77	57.54	27.38	16.31	27.69	18.46	13.54
Minimum	-32.31	-1.23	-29.85	-29.23	-8.00	-16.31	13.54
Difference	51.08	58.77	57.23	45.54	35.69	34.77	0

Table 8 contains 9 negative dates and 13 dates older than the Big Bang explosion and a 90-billion-year age range. **(Wanajo, 2002, Page 863)**

Lead And Thorium In The Early Galaxy

Roederer’s calculations are based on a long list of unproven assumptions listed below. The dates obtained [Table 9] have an impossible 24.8-billion-year range.

“This explicitly assumes that the four r-process standard stars contain no amount of s-process material.” **(Roederer, 2009, page 1971)**

“These stellar ratios are compared with our predictions, made using the classical waiting-point assumption—defined as an equilibrium condition between neutron captures and photo disintegrations.” **(Roederer, 2009, page 1973)**

“Although this approach makes the simplifying assumptions of constant neutron number density and temperature as well as instantaneous nuclear freezeout, the equilibrium model calculations reproduce the S.S. abundances well.” **(Roederer, 2009, page 1973)**

“Our approach can be considered reliable only if we achieve a “consistent” picture—meaning that the abundances are solar—with logical astrophysical assumptions for the three heaviest r-process observables.” **(Roederer, 2009, page 1973)**

“The specific calculations employed here assume a weighted range of neutron number densities (from 10²³ to 10³⁰ cm⁻³).” **(Roederer, 2009, page 1973)**

“We also assume a varying r-process path related to contour lines of constant neutron separation energies in the range of 4–2 MeV.” **(Roederer, 2009, page 1973)**

“Assuming the stellar Pb abundances are not seriously in error, we currently lack a complete, self-consistent understanding of r-process nucleosynthesis and enrichment for all low metallicity stars.” **(Roederer, 2009, page 1976)**

“The horizontal lines indicate the ratios expected if a sample of material had a given age, assuming the nucleosynthesis predictions of Kratz.” **(Roederer, 2009, page 1977)**

“If we divide the sample into two groups of stars—those with an actinide boost and those without—and assume a single age for each group, we can derive reasonable estimates for the age of the r-process-only standard stars, as shown in Table 9.” **(Roederer, 2009, page 1977)**

“Assuming that the observed stellar ratios are independent (which they clearly are not since all rely on Th), we derive an age for the ensemble of standard r-process-only stars of 15.2 ± 2.1 (σ = 4.6) Gyr.” (Roederer, 2009, page 1977)

Table 9

Method	Age (Ga)	Age (Ga)	Difference
Th/La	20.4	6.4	14
Th/Eu	10.6	-4.4	15
Th/Er	13.2	1.5	11.7
Th/Hf	19.7	3.4	16.3
Th/Ir	11.7	-2.3	14
Th/Pb	9.9		

(Roederer, 2009, Page 1978)

Actinides: Their Stellar Production

Goriely’s calculations are based on a long list of unproven assumptions listed below. The dates obtained [Table 10] have an impossible 21-billion-year range.

“The canonical model assumes that some stellar material composed solely of iron nuclei is subjected to neutron densities and temperatures that remain constant over the whole neutron irradiation time.” **(Goriely, 2001, Page 1114)**

“This is even more true if different types of r-process episodes have to be considered, at least if the assumption of the “universality” of the r-process yields is not adopted from the start.” **(Goriely, 2001, Page 1115)**

“The long-lived 232Th/238U and 235U/238U pairs have been classically used to estimate the age of the r-nuclides (assumed to be roughly equal to the age of the Galaxy) from the present meteoritic content of these nuclides.” **(Goriely, 2001, Page 1117)**

“The major origin of the difficulty lies in the necessity to make the assumption that the r-process is universal.” **(Goriely, 2001, Page 1118)**

“In these conditions, the universality assumption would lead to quite odd chronometric conclusions. In particular, the Th/Eu ratio in CS 31082-001 is about 3.2 times larger than in CS 22892-052. Hence, under the universality assumption, CS 22892-052 predates CS 31082-001 by 24 Gy, and would thus be about 36 Gy old.” **(Goriely, 2001, Page 1118)**

“In these conditions, and if the universality of the Pb/Th ratio is assumed, the observed Pb/Th values turn out to be discrepant by a factor of about 10, at least if the two stars have roughly the same age. If this is indeed the case (which is not a farfetched assumption in view of their similar [Fe/H] ratio), either the universality assumption is invalid, and a specific actinide-producing r-process has to be called for, or the Pb in CS 22892-052 is largely of s-process origin.” **(Goriely, 2001, Page 1118)**

“Even if the assumption of a universal r-process appears to be more and more fragile with time, we dare suppose in the following that it indeed holds in order to examine if constraints can be put in such a favorable situation on the nuclear and astrophysical models for use in r-process calculations, and consequently on the actinide production.” **(Goriely, 2001, Page 1118)**

“This clearly contradicts the universality assumption which is the basis of all the chronometric considerations making use of metal-poor stars.” **(Goriely, 2001, Page 1120)**

“Second, the constraints adopted to select the recommended actinide productions and their ranges of variations given in Tables 1 and 2, while admittedly highly subjective, appear reasonable to the authors only under the assumption of the universality of the r-process. At discussed above, this basic assumption appears to be more and more questionable as data accumulate. As a direct consequence, the derived constraints are increasingly unsecure.” **(Goriely, 2001, Page 1120)**

“A single r-process production is assumed at time zero.” **(Goriely, 2001, Page 1121)**

Seven Eu/U dates are over 16 billion years old. Six Eu/Th dates are over 16 billion years old.

Table 10

Case	U/Th	U/Eu	Case	U/Th	U/Eu
Number	Age (Ga)	Age (Ga)	Number	Age (Ga)	Age (Ga)
1	13.55	8.38	17	11.58	5.73
2	12.48	7.81	18	10.57	4.74
3	13.54	8.14	19	11.97	4.75
4	13.92	10.16	20	14.57	11.14
5	8.94	7.86	21	10.77	8.49
6	16.14	20.52	22	13.39	18.03
7	13.66	2.88	23	11.59	1.71
8	14.3	13.2	24	15.81	15.46
9	14.3	13.15	25	20.09	16.12
10	12.31	10.43	26	10.13	7.47
11	17.73	16.23	27	16.18	13.08
12	14.65	12.67	28	12.74	8.87
13	13.56	13.38	29	15.38	15.87
14	16.11	22.6	30	13.61	20.64
15	17.31	16.86	31	15.45	16.28
16	14.02	14.43	32	10.94	13.06

(Goriely, 2001, Page 1119)

Table 10 contains 27 dates older than the Big Bang explosion and a 20-billion-year age range. Lowest age is 1.71 Ga and the oldest is 22.6 Ga.

The halo giant CS 31082-001

(Hill, 2002)

“It is difficult to conceive any reasonable scenario that would account for this by an age difference: CS 22892-052 and HD115444 would then be 20 and 18 Giga years older than CS 31082-001, respectively (regardless of the adopted production ratio for Th/Eu), which seems unrealistic.” **(Hill, 2002, Page 573)**

“Using the same initial production ratio as in Cayrel, this leads to an age of almost 17 Ga, 4.3 Ga greater than that originally published. By contrast, use of the conventional Th/Eu chronometer leads instead to a slightly negative (!), or at most a T-Tauri like age for CS 31082-001.” **(Hill, 2002, Page 574)**

The Thorium Chronometer

(Cowan, 1997)

Table 11

Source	Th/Eu	Age(Ga)	Error
Solar system:	0.463	15.2	3.7
Theory 1:	0.479	15.9	2
No Fission	0.499	16.7	2
Less consistent	0.502	16.8	2
Theory 2	0.427	13.5	2

(Cowan, 1997, Page 248)

Several quotes from this article give absurd ages:

“These Galactic chemical evolution models suggest an age of 17 Ga for CS 22892-052.” **(Cowan, 1997, Page 246)**

“This function is plotted in Figure 8 for disk ages, t_d, of 8, 10.5, and 15 Ga, and an age for the solar material, t of 4.6 Ga; the implied age estimate, of 18.1 +/- 4 Ga, from the observed N(Th/Eu) in CS 22892-052 is indicated on the figure; if the ratio of Th to all r-process elements is used an age of 16.3 Ga results.” **(Cowan, 1997, Page 252)**

“Age dependence of the observed Th/r ratio (in units of the observed solar system value), based on a simple model of chemical evolution and three different assumed ages for the Galactic disk. Galactic disk ages of 8, 10.5, and 15 Ga are indicated. The horizontal lines represent the observed Th/r ratio in CS 22892-052 with 1 p uncertainty; the best-fit age is 18 Ga, with an acceptable range from 14 to 22 Ga.” **(Cowan, 1997, Page 252)**

“In this circumstance the most likely age of the CS 22892-052 material is 17-18 Ga.” **(Cowan, 1997, Page 253)**

“Our Galactic evolution models therefore suggest an age of 17 Gyr for CS 22892-052, with an inferred disk age of 10.5 Gyr.” **(Cowan, 1997, Page 253)**

Chronometers In Metal-Poor Stars

Several quotes from this article admit that unprovable assumptions underly his calculations:

“These theoretical computations assume the classical waiting point approximation of (n, c) $\nrightarrow$ (c, n) equilibrium.” **(Cowan, 1999, page 194)**

“We assume, as a working hypothesis, that the heavy element abundances of very low metallicity stars are given by a pure r-process composition. This assumption is supported by the observational evidence, at least for the elements beyond Ba, for which data are available. We have analyzed r-process abundances with predictions from calculations in the waiting-point assumption.” **(Cowan, 1999, page 196)**

“The major remaining question is related to the assumption of an (n, c) $\nrightarrow$ (c, n) equilibrium during the freeze-out phase in realistic astrophysical sites and depends on the temporal decline pattern of neutron density and temperature below the above-mentioned limits.” **(Cowan, 1999, page 196)**

“However, the disadvantage is that these highly advanced and computationally expensive calculations still assume spherical symmetry for all nuclei.” **(Cowan, 1999, page 198)**

“Applying them in Galactic evolution models, which include assumptions about the histories of star formation rates and r-process production” **(Cowan, 1999, page 200)**

“The major remaining contamination of the Th II feature is due to Co I (chiefly at 4019.3 Angstroms), and we altered the assumed Co abundance to match this absorption.” **(Cowan, 1999, page 201)**

One of the dates calculated is over 40 billion years old.

Table 12

Model	⁹⁰ Th	⁶³ Eu	Th/Eu	Age (Ga)
Solar	0.042	0.09	0.463	13.8
FRDM	0.0428	0.0242	1.7695	41.0
ETFSI-1	0.02949	0.06041	0.4881	14.9
HFB/SkP	0.01991	0.05134	0.3879	10.2
FRDM-HFB	0.03449	0.06958	0.4957	15.2
ETFSI-Q	0.06292	0.11533	0.5456	17.1
ETFSI-Q(lsq)	0.04222	0.08788	0.4804	14.5

(Cowan, 1999, Page 202)

“This led to the exclusion of the mass models of Hilf, FRDM, and ETFSI-1. FRDM is listed in Table 3, but the Eu abundance prediction is off by a factor of more than 3, underlining the previous finding and therefore making the age prediction meaningless.” (Cowan, 1999, Page 203)

Thorium Ages For Metal-Poor Stars

Several quotes from Johnson’s article admit that unprovable assumptions underly her calculations:

“We obtain an average age of 11.4 Gyr, which depends critically on the assumption of an initial Th/Eu production ratio of 0.496. If the universe is 15 Gyr old, then the (Th/Eu) should be 0.590, in agreement with some theoretical models of the r-process.” (Johnson, 2001, page 888)

“A second significant source of uncertainty in the Th-based ages is the assumption that the r-process abundance pattern for elements from Ba to Th is universal and that the abundance of elements such as Ba, Eu, Nd, and Sm can be used to estimate the initial Th abundance in a star.” (Johnson, 2001, page 888)

“For the rest of our analysis, we assume that the heavy-element abundances in our sample of stars represent contributions from the r-process only.” (Johnson, 2001, page 899)

“We are assuming that the metal enrichment for these metal-poor stars happened over a short period of time, so we do not need to model Galactic chemical history).” (Johnson, 2001, page 900)

“Our mean age is based on the assumption of a universal r-process pattern.” (Johnson, 2001, page 901)

“If we assume that all the metal-poor stars for which we have measured Th are coeval, we can put a limit on the observed dispersion in the initial Th/Eu ratio. Table 7 gives this value assuming that all the stars are 12 Gyr old.” (Johnson, 2001, page 901)

“They found an average age of 14.5 Gyr, again close to ages derived for the MSTO, assuming (Th/Eu) = 0.496 as in this paper.” (Johnson, 2001, page 888)

Table 13

Star	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)
HD 186478	16.8	16.8	18.3	18.3
HD 115444	4.2	9.8	6.1	11.2
HD 108577	9.3	8.4	10.6	9.8
BD 82548	9.3	7.5	10.8	8.9
M92 VII-18	6.5	7.5	7.9	8.8

(Johnson, 2001, Page 900)

Table 14

Stars	Age (Ga)	Age (Ga)	Age (Ga)
Name	Maximum	Minimum	Difference
HD 186478	22.50	14.14	8.36
HD 115444	15.42	3.00	12.42
HD 108577	14.54	5.63	8.91
BD 82548	14.78	4.67	10.11
M92 VII-18	14.46	3.00	11.46

(Johnson, 2001, Page 901)

Neutron Capture–Rich Star CS 22892-052

“Thorium is radioactive with a half-life of 14.0 Gyr, and the observed [Th/Eu] abundance ratio combined with an assumed extrapolation of the solar system r-process abundance distribution out to Th yielded a simple ‘decay age’ of about 15 Gyr.” (Sneden, 2003, page 937)

“Assuming that CS 22892-052 began its life with a ‘Spite plateau’ Li abundance of log 2.0.” (Sneden, 2003, page 942)

“Both of these effects must be carefully accounted for in synthetic spectrum computations, and still the derived abundances from such deep and saturated absorption features are dependent on assumed values of microturbulent velocity.” (Sneden, 2003, page 945)

“This distribution, indicated by the solid line, is based on n-capture cross section measurements and assumes the “classical” s-process empirical relation between abundance and cross section.” (Sneden, 2003, page 946)

“We proceed now on the assumption that the robustness in the heavy region continues through the actinides, so that we can utilize abundance data concerning the interesting actinide radioactivity 232 Th, 235 U, and 238 U to date the star.” (Sneden, 2003, page 948)

“These chronometric age estimates, however, depend sensitively on the predicted initial values of the radioactive elements, in ratio to each other, or to stable elements. To determine these initial ratio values, we have utilized the theoretical r-process predictions described in 4.2.” (Sneden, 2003, page 948)

“An average of the chronometer pairs, assuming initial solar system ratios, gives an age of 14.7 Gyr, which is not inconsistent with the average based on theoretically predicted r-process abundance ratios.” (Sneden, 2003, page 949)

Table 15

Dating	Average	Lower Limit
Method	Age (Ga)	Age (Ga)
Th/Eu	12.8	13.2
Th/Ir	19.2	13.1
Th/Pt	10.5	17.7
Th/U	10.4	

The R-Process In Supernova Explosions

(Wanajo, 2003)

Table 16

Th/Eu	U/Th	Difference	Th/Eu	U/Th	Difference
Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)
-2.50	7.72	10.22	23.37	14.75	8.62
4.00	9.51	5.51	23.11	14.75	8.36
6.72	13.09	6.37	21.71	14.75	6.97
8.51	13.95	5.44	20.32	14.75	5.57
10.04	14.75	4.71	18.60	14.75	3.85
11.36	14.75	3.38	16.74	14.75	1.99
12.56	14.75	2.19	15.08	14.75	0.33
13.55	14.75	1.19	13.36	14.75	1.39
14.35	14.75	0.40	11.96	14.75	2.79
15.41	14.75	0.66	10.57	14.75	4.18
16.54	14.75	1.79	8.98	14.75	5.77
17.53	14.75	2.79	7.78	14.75	6.97
19.19	14.75	4.44	6.39	14.75	8.36
20.72	14.75	5.97	5.53	14.75	9.22
23.37	14.75	8.62	4.47	14.75	10.28

Table 16 contains 1 negative date and 41 dates older than the Big Bang explosion and a 26-billion-year age range.

(Wanajo, 2003, Page 977)

“The age Th/Eu is sensitive to the parameter M, ranging from a negative age to 23.8 Gyr, which illustrates that caution must be used in the application of this chronometer pair.”

(Wanajo, 2003, Page 977)

Accuracy of Radioactive Dating of Stars

(Ludwig, 2010)

Table 17 (Part A)

Isotope	Object	Th/Eu	Th/Hf	Th/Os	Th/Ir	Max	Min
Ratios	Name	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]
Th/Eu	BD+173248	7.6	6.3	8.3	10.5	10.5	6.3
Th/Ir		20.7	14	19.1		20.7	14
Th/Os		27.7	22			27.7	22
Th/Eu	BD+82856	7.3	5.8	8	9.6	9.6	5.8
Th/Eu	CS22892-052	14.8	13.4	15.4	17.6	17.6	13.4
Th/Eu		15.4	13.1	15	17.3	17.3	13.1
Th/Eu		12.1	11.7	13.7	15.9	15.9	11.7
Th/Hf		27.7				27.7	27.7
Th/Hf		24.6				24.6	24.6
Th/Ir		25.8	19.1	25.2		25.8	19.1
Th/Ir		19	13.3	19.4		19.4	13.3
Th/Os		19.6	14.8			19.6	14.8
Th/Os		24.4	18.6			24.4	18.6
Th/Os		26	20.3			26	20.3
Th/Eu	CS31082-001	0.9	-1.5	0.5	2.7	2.7	-1.5
Th/Hf		15.2				15.2	15.2
Th/Ir		6.5	-0.2	5.9		6.5	-0.2
Th/Os		17.9	12.1			17.9	12.1
U/Th		16.6	13.3	14.6		16.6	13.3
Th/Eu	HD108577	7.8	6.2	8.4	10.1	10.1	6.2
Th/Eu	HD115444	11.7	10.4	12.3	14.6	14.6	10.4
Th/Eu		9.6	8.1	10.3	11.9	11.9	8.1
Th/Os		30.1	24.3			30.1	24.3
Th/Eu	HD186478	16.6	15.1	17.3	18.9	18.9	15.1
Th/Eu	HD221170	11.7	10.4	12.3	14.6	14.6	10.4
Th/Hf		21.9				21.9	21.9
Th/Ir		20.7	14	19.1		20.7	14
Th/Os		27.1	22.3			27.1	22.3

(Ludwig, 2010, Page 5)

Table 17 (Part B)

Isotope	Object	Th/Eu	Th/Hf	Th/Os	Th/Ir	Max	Min
Ratios	Name	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]	[Ga]
Th/Eu	HE1523-0901	11.4	9.5	11	13.2	13.2	9.5
Th/Ir		18	12.3	17.4		18	12.3
Th/Os		16.9	10.1			16.9	10.1
U/Th		15				15	15
Th/Hf	M4-L1411	32.5				32.5	32.5
Th/Hf		32.5				32.5	32.5

Th/Hf	M4-L1501	25.5				25.5	25.5
Th/Hf	M4-L1514	37.2				37.2	37.2
Th/Hf	M4-L2406	32.5				32.5	32.5
Th/Hf	M4-L2617	23.2				23.2	23.2
Th/Hf	M4-L3209	30.2				30.2	30.2
Th/Hf	M4-L3413	23.2				23.2	23.2
Th/Hf	M4-L4511	27.8				27.8	27.8
Th/Hf		37.2				37.2	37.2
Th/Eu	M51-K341	11	9.7	12.6	13.9	13.9	9.7
Th/Eu	M51-K462	14.1	12.7	14.7	16.9	16.9	12.7
Th/Eu	M51-K583	6.6	4.3	7.2	8.5	8.5	4.3
Th/Hf	M5-IV-81	18.5				18.5	18.5
Th/Hf	M5-IV-82	18.5				18.5	18.5
Th/Eu	M92-VII-18	6.8	5.3	7.5	9.1	9.1	5.3
Th/Eu	Sun	3.3	1.7	3.9	5.6	5.6	1.7
Th/Hf		22.3				22.3	22.3
Th/Ir		10.1	4	9.6		10.1	4
Th/Os		14.1	8.6			14.1	8.6

(Ludwig, 2010, Page 5)

Table 17 contains 36 dates older than the Big Bang explosion and a 39-billion-year age range.

Table 18

Object	Max	Min	Difference
Name	[Gyr]	[Gyr]	[Gyr]
BD+173248	27.7	6.3	21.4
BD+82856	9.6	5.8	3.8
CS22892-052	27.7	11.7	16
CS31082-001	17.9	-1.5	19.4
HD108577	10.1	6.2	3.9
HD115444	30.1	8.1	22
HD186478	18.9	15.1	3.8
HD221170	27.1	10.4	16.7
HE1523-0901	17.4	9.5	7.9
M4-L1411	32.5		
M4-L1501	25.5		
M4-L1514	37.2		
M4-L2406	32.5		
M4-L2617	23.2		
M4-L3209	30.2		
M4-L3413	23.2		
M4-L4511	37.2		
M51-K341	13.9	9.7	4.2
M51-K462	16.9	12.7	4.2
M51-K583	8.5	6.6	1.9
M5-IV-81	18.5		
M5-IV-82	18.5		
M92-VII-18	9.1	5.3	3.8
Sun	22.3	1.7	20.6

A summary of table 17.

Figure 1.

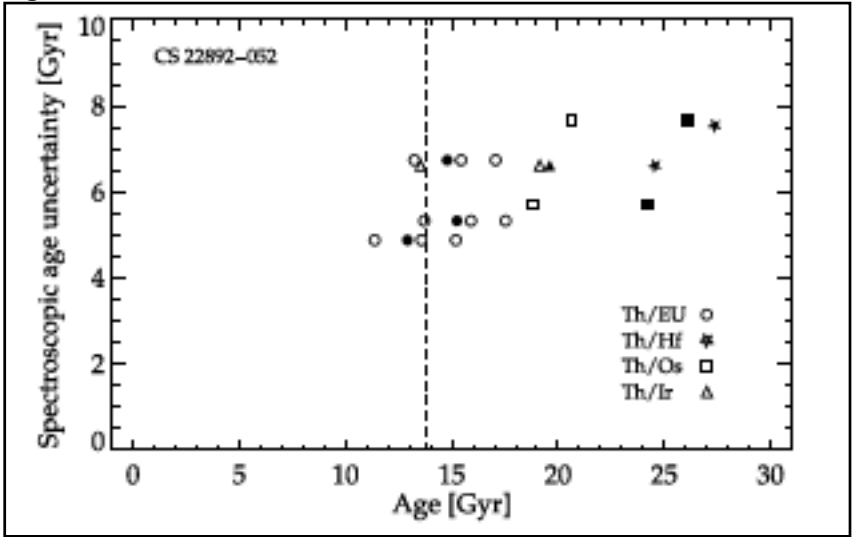


Figure 1. Ages and spectroscopic age uncertainties for star CS 22892-052 determined from various chronometer pairs (symbols) assuming up to four different production ratios. Filled symbols refer to the production rations of Kratz. The dashed line indicates the age of the universe. Sneden give a radio chronometric age estimate of 14.2 ± 3 Gyr for this star. (Ludwig, 2010, Page 5)

The Th/Hf age, 22.3 Gyr, comes out to be greater than the age of the universe, 13.73 Gyr, as estimated from the fluctuations of the Cosmic Microwave Background. (Ludwig, 2010, Page 6)

Gyro Chronological and isochronal age estimates

(Maxted, 2015)

Table 21

Stars	Isochrone	Gyrochronology	Tidal Age	Tidal Age
Name	Age (Gyr)	Age (Gyr)	10 ⁹ Years	10 ¹² Years
55-Cnc	10.91	8.1	6,310	6.310
CoRoT-2	2.66	0.17	20	0.020
CoRoT-4	2.1	1.81	199,526	200
CoRoT-6	3.4	0.35	10,000	10
CoRoT-7	2.92	2.8	12,589	12.589
CoRoT-13	5.99	2.34	794	0.794
CoRoT-18	10.69	0.22	16	0.016
HAT-P-11	0.72	3.89	5,011,872	5,012
HAT-P-21	9.52	1.64	126	0.126
HATS-2	9.7	3.1	32	0.032
HD-189733	4.75	0.71	794	0.794
HD-209458	2.42	1.83	3,162	3.162
Kepler-17	1.48	1.43	20	0.020
Kepler-30	4.38	1.47	10,000,000,000	10,000,000
Kepler-63	3.16	0.23	6,309,573	6,310
Qatar-2	15.72	0.64	16	0.016
WASP-4	6.27	2.72	40	0.040
WASP-5	5.84	2.13	32	0.032
WASP-10	6	0.66	398	0.398
WASP-19	9.95	0.89	3	0.003
WASP-41	8.25	1.71	1,995	2
WASP-46	10.03	1.23	20	0.020
WASP-50	8.57	1.3	158	0.158
WASP-69	15.2	2.09	79,433	79.433
WASP-77	7.57	1.35	20	0.020
WASP-84	1.89	0.99	501,187	501
WASP-85	2.09	1.5	1,000	1.000
WASP-89	12.07	1.88	79	0.079

Table 21 contains 28 dates [blue] older than the Big Bang explosion and a ten million trillion-year age range. Purple squares are twelve dates > one trillion years old.

Analysis of very metal-poor r-I stars

(Mello, 2014)

Table 22

Dating Method	CS 31082-001 Age (Gyr)	CS 30315-029 Age (Gyr)	Dating Method	CS 31082-001 Age (Gyr)	CS 30315-029 Age (Gyr)
Th/La	-11.21	-10.01	Th/Gd	-1.87	-9.81
	16.35	17.55		55.57	47.63
	22.42	23.62		18.68	10.74
Range	33.63	33.63	Range	57.44	57.44
Th/Ce	-4.67	0.25	Th/Tb	-7.01	-3.27
	35.03	39.94		32.69	36.43
	20.55	25.47		21.02	24.75
Range	39.70	39.70	Range	39.70	39.70
Th/Pr	-5.14	1.03	Th/Dy	0.93	-2.8
	36.89	43.06		39.23	35.49
	20.55	26.71		36.43	32.69
Range	50.03	42.03	Range	38.30	38.30
Th/Nd	-3.74	-0.86	Th/Er	0	0.93
	26.62	29.5		30.82	31.76
	7.01	9.88		18.68	19.61
Range	30.35	30.35	Range	30.82	30.83
Th/Sm	-1.87	4.2	Th/Tm	-2.34	-6.77
	26.62	32.69		22.42	17.98
	13.54	19.61		12.61	8.17
Range	28.49	28.49	Range	24.76	24.76
Th/Eu	-2.8	-5.32			
	-1.4	-3.92			
	-3.27	-5.79			
	14.48	11.96			
	-5.14	-7.66			
	35.03	32.5			
	15.41	12.89			
Range	40.17	39.17			

Negative dates [Red] and dates [Blue] older than the Big Bang. Table 22 contains 9 negative dates and 22 dates older than the Big Bang explosion and a 67-billion-year age range.

Chromospherically young, Kinematically old stars

(Rocha-Pinto, 2002)

Table 23

Chromosphere	Isochrone	Age	Age
Age (Ga)	Age (Ga)	Difference	Ratio
0.28	1.3	1.02	4.64
0.50	1.8	1.30	3.60
2.07	2.0	0.07	0.97
0.38	2.3	1.92	6.05
4.70	2.6	2.10	1.81
6.43	7.4	0.97	1.15
1.14	8.5	7.36	7.46
0.49	8.7	8.21	17.76
2.53	10	7.47	3.95
5.39	13	7.61	2.41
4.16	13.8	9.64	3.32
7.91	18	10.09	2.28
3.92	18.9	14.98	4.82

Table 23 contains 3 dates older than the Big Bang explosion and an 18-billion-year age range.

Pulsars in globular clusters

A radio pulsar’s characteristic age τ (seconds) is usually defined as:

$$\tau = \frac{P}{2\dot{P}} = \frac{P}{2dP/dt}$$

Where P is the pulsar’s period, and the dot represents the period derivative (the rate the pulsar is slowing).
10 dates over one trillion years old. Maximum age of 20,000 trillion years.

Table 24

Cluster	Pulsar	10 ⁶ Years	10 ⁹ Years	10 ¹² Years
NGC 104	J0023-7204C	-2		
	J0024-7204D	-2		
	J0024-7204G	-15,188	-15	
	J0024-7204H	-2,779,496	-2,779	-2.779
	J0024-7204I	-12,038	-12	
	J0024-7204L	-56		
	J0023-7205M	-1,515	-2	
	J0024-7204Q	18,784	19	
	J0024-7204S	-3,720	-4	
	J0024-7204T	40,937	41	
	J0024-7203U	72,255	72	
	J0024-7204W	-430,610	-431	
	J0024-7201X	4,117,455	4,117	4.117
	J0024-7205Z	-1,582,476	-1,582	-1.582
	J1342+2822B	2,037,213	2,037	2.037
	B1620-26	-3,209	-3	
M13	B1639+36A	-22,524	-23	
	B1639+36B	-55,898,896	-55,899	-55.899
	J1641+3627D	-209,349	-209	
	J1641+3627E	22,516	23	
M92	J1717+4308A	818,942	819	
NGC 6342	B1718-19(A)	1,000,506,531	1,000,507	1,000.507
M14	J1737-0314A	328,491	328	
Terzan 5	J1748-2446A	-6,317,512	-6,318	-6.318
	J1748-2446C	-22		
	J1748-2446D	574,527	575	0.575
	J1748-2446E	-1,934,558	-1,935	-1.935
	J1748-2446F	21,944,555	21,945	21.945
	J1748-2446G	880,437	880	0.880
	J1748-2446H	-940,313	-940	-0.940
	J1748-2446I	-2,135,641	-2,136	-2.136
	J1748-2446J	509,151	509	0.509
	J1748-2446K	-500,545	-501	-0.501
	J1748-2446L	-2,092,066	-2,092	-2.092
	J1748-2446M	115,421	115	0.115
	J1748-2446N	249,670	250	0.250
	J1748-2446O	-384,994	-385	-0.385
	J1748-2446P	105,340	105	0.105
	J1748-2446Q	-1,237,596	-1,238	-1.238
	J1748-2446R	169,516	170	0.170
	J1748-2446S	1,514,255	1,514	1.514
	J1748-2446T	362,108	362	0.362
	J1748-2446U	173,711	174	0.174

	J1748-2446V	-345,652	-346	-0.346
	J1748-2446W	555,225	555	0.555
	J1748-2446X	805,431	805	0.805
	J1748-2446Y	216,341	216	0.216
	J1748-2446Z	-453,691	-454	-0.454
	J1748-2446aa	-208,423	-208	-0.208
	J1748-2446ab	193,136	193	0.193
	J1748-2446ac	350,423	350	0.350
	J1748-2446ad	-650,515	-651	-0.651
	J1748-2446ae	-101,696	-102	-0.102
	J1748-2446af	-227,627	-228	-0.228
	J1748-2446ag	5,872,899	5,873	5.873
	J1748-2446ah	138,014	138	0.138
	J1748-2446ai	240,245	240	0.240
NGC 6440	B1745-20	1,145,077,656	1,145,078	1,145.078
NGC 6517	J1801-0857A	-22		
	J1801-0857C	-9,113	-9	
	J1801-0857E	-116,144	-116	
	J1801-0857F	-147,601	-148	
	J1801-0857H	24,834	25	
NGC 6522	J1803-3002A	281,287	281	
NGC 6544	J1807-2459A	-11,182	-11	
NGC 6624	B1820-30B	19,042,830,625	19,042,831	19,042.831
	J1823-3021C	2,871,266,125	2,871,266	2,871.266
	J1823-3021G	-53,617	-54	
M28	J1824-2452D	1,288,101,892	1,288,102	1,288.102
M22	J1836-2354A	22,928	23	
	J1836-2354B	-107		
NGC 6712	J1853-0842A	-14,312,897	-14,313	-14.313
NGC 6752	J1910-5959E	-16,576	-17	
NGC 6760	J1911+0102A	-8,713,068	-8,713	-8.713
	J1911+0101B	-42,654,701	-42,655	-42.655
M71	J1953+1846A	1,596,719	1,597	1.597
M15	B2127+11H	223,117	223	

(Freire, 2021)

Millisecond pulsars in 47 Tucanae

Table 25

Pulsar	Age (Ga)	Pulsar	Age (Ga)
H	-31,379	L	-565
D	-25,484	T	408
J	-3,401	E	569
N	-2,213	F	644
C	-1,830	U	722
M	-1,520	O	1,381
G	-1,519	Q	1,873

(Freire, 2001)

CSIRO Pulsar Catalogue

67 dates over 14 billion years old.
 34 dates with future ages.
 2 trillion-year age range.

Table 26

Pulsar	Age 1	Age 2	Pulsar	Age 1	Age 2
ID	Myr.	Myr.	ID	Myr.	Myr.
B0021-72C	.	-1,750	J1641+8049	3,580	-2,420
B0021-72D	.	-17,600	J1653-0158	13,000	39,000
B0021-72G	.	-1,470	J1658+3630	4,520	14,600
B0021-72H	.	-16,600	J1709+2313	20,200	68,400
B0021-72I	.	-1,170	J1710+4923	2,800	208,000
B0021-72J	.	-3,090	J1721-2457	10,000	-31,700
B0021-72L	.	-559	J1745+1017	15,400	18,700
B0021-72M	.	-1,470	J1757-2745	.	-258
B0021-72N	.	-2,060	J1801-1417	10,800	14,200
B2127+11A	.	-83	J1801-3210	1,640,000	-34,000
J0024-7204S	.	-369	J1804-2858	.	-4,250
J0024-7204W	.	-425	J1813-2621	5,630	-12,100
J0024-7204Y	.	-968	J1821+0155	18,500	.
J0024-7204Z	.	-13,300	J1832-0836	5,210	-219,000

J0154+1833	12,800	31,400	J1836-2354A	22,900	.
J0509+0856	14,600	16,000	J1843-1448	14,000	-15,700
J0514-4002A	113,000	-24,000	J1904+0451	16,900	.
J0610-2100	4,950	51,000	J1905+0400	12,200	14,100
J0645+5158	28,500	41,500	J1906+0454	11,100	-18,100
J0931-1902	20,200	28,200	J1909-3744	3,330	16,500
J1017-7156	16,700	17,900	J1910-5959A	17,600	24,100
J1024-0719	4,410	-2,270	J1910-5959C	38,700	393,000
J1101-6424	45,000	.	J1933-6211	14,500	18,400
J1103-5403	14,600	.	J1938+2012	55,600	.
J1125+7819	9,570	-201,000	J1938+6604	18,100	.
J1142+0119	5,360	-286	J1946+3417	16,100	-84,300
J1207-5050	12,700	14,400	J1955+6708	10,800	240,000
J1216-6410	34,700	.	J2010+3051	15,700	-20,000
J1327-0755	23,900	-27	J2010-1323	17,200	21,200
J1400-1431	6,760	155,000	J2017-1614	15,000	.
J1405-4656	4,320	-125,000	J2019+2425	8,880	47,200
J1417-4402	.	-30,800	J2034+3632	33,600	.
J1421-4409	8,180	16,900	J2055+3829	33,100	196,000
J1518+4904	23,900	32,200	J2129-0429	.	-13,900
J1603-7202	15,000	16,200	J2222-0137	8,960	35,400
J1618-4624	30,300	.	J2229+2643	31,100	45,100
J1622-0315	5,250	-10,300	J2317+1439	22,500	25,200
J1640+2224	17,800	39,400	J2322+2057	7,890	26,500
J1641+3627C	47,800	.	J2322-2650	94,100	125,000

(CSIRO, 2021)

Millisecond Pulsar Ages

Table 27

Pulsar	τc(Ga)	τci(Ga)	τ(Ga)	τi(Ga)	τc/τ	Max	Min	Diff.
J0034−0534	6	55.71	4.29	39.9	0.15	55.71	4.29	51.42
J1709+2313	20.21	49.45	19.27	47.15	0.43	49.45	19.27	30.18
J1730−2304	6.37	42.92	6.24	42.27	0.15	42.92	6.24	36.68
J2317+1439	22.55	36.18	20.65	33.13	0.68	36.18	20.65	15.53
J1905+0400	12.34	33.12	11.47	30.81	0.4	33.12	11.47	21.65
J1640+2224	17.71	30.59	15.94	27.53	0.64	30.59	15.94	14.65
J1518+4904	23.84	29.34	23.74	29.23	0.82	29.34	23.74	5.6
J2019+2425	8.88	24.34	8.31	22.77	0.39	24.34	8.31	16.03
J2322+2057	7.85	18.49	7.51	17.69	0.44	18.49	7.51	10.98
J1629−6902	9.51	18.16	9.24	17.66	0.54	18.16	9.24	8.92
J1603−7202	14.98	17.94	14.85	17.81	0.84	17.94	14.85	3.09
J0610−2100	4.93	17.92	4.6	16.72	0.3	17.92	4.6	13.32
J2010−1323	17.17	1.5	16.54	1.800	0.1	17.17	1.5	15.67
J1909−3744	3.34	17.08	2.95	15.12	0.22	17.08	2.95	14.13
J1125−6014	10.39	16.37	8.89	14.00	0.74	16.37	8.89	7.48
J1721−2457	9.39	15.93	8.62	14.62	0.64	15.93	8.62	7.31
J2033+17	8.57	14.86	8.33	14.44	0.59	14.86	8.33	6.53
B1257+12	0.86	14.58	0.75	14.21	0.06	14.58	0.75	13.83

(Kiziltan, 2010)

Obliquities Of Hot Jupiter Host Stars

339,600 trillion-year age range.

Table 28

No.	10 ⁶ Years	10 ⁹ Years	10 ¹² Years	No.	10 ⁶ Years	10 ⁹ Years	10 ¹² Years
1	13,273.03	13.27	0.01	24	15,957,689.28	15,957.69	15.96
2	20,652.38	20.65	0.02	25	14,824,156.95	14,824.16	14.82
3	25,291.23	25.29	0.03	26	22,231,563.37	22,231.56	22.23
4	30,972.05	30.97	0.03	27	20,275,426.77	20,275.43	20.28
5	31,547.87	31.55	0.03	28	35,234,653.45	35,234.65	35.23
6	91,826.92	91.83	0.09	29	49,087,397.15	49,087.40	49.09
7	135,197.92	135.20	0.14	30	64,709,792.07	64,709.79	64.71
8	142,879.53	142.88	0.14	31	935,341,070.18	935,341.07	935.34
9	214,274.26	214.27	0.21	32	1,686,436,543.29	1,686,436.54	1,686.44
10	239,315.05	239.32	0.24	33	3,723,659,869.53	3,723,659.87	3,723.66
11	248,296.16	248.30	0.25	34	7,498,424,177.51	7,498,424.18	7,498.42
12	298,517.64	298.52	0.30	35	11,667,290,311.41	11,667,290.31	11,667.29
13	439,511.26	439.51	0.44	36	14,824,156,947.62	14,824,156.95	14,824.16
14	635,287.05	635.29	0.64	37	16,556,556,074.13	16,556,556.07	16,556.56

15	1,303,076.77	1,303.08	1.30	38	25,761,432,229.09	25,761,432.23	25,761.43
16	1,566,642.86	1,566.64	1.57	39	33,340,338,460.68	33,340,338.46	33,340.34
17	1,749,725.84	1,749.73	1.75	40	30,406,750,063.94	30,406,750.06	30,406.75
18	1,883,518.99	1,883.52	1.88	41	74,984,241,775.12	74,984,241.78	74,984.24
19	2,437,642.45	2,437.64	2.44	42	80,717,927,841.32	80,717,927.84	80,717.93
20	2,930,690.82	2,930.69	2.93	43	102,558,108,941.28	102,558,108.94	102,558.11
21	3,213,438.59	3,213.44	3.21	44	159,576,892,755.04	159,576,892.76	159,576.89
22	4,908,739.72	4,908.74	4.91	45	339,601,816,308.59	339,601,816.31	339,601.82
23	12,105,145.23	12,105.15	12.11				

(Albrecht, 2012)

Age and metallicity of stellar populations

56 dates over 14-billion years old.

Table 29

Id	Best Age	Lowest Age	Upper Age	Id	Best Age	Lowest Age	Upper Age
Number	Ga.	Ga.	Ga.	Number	Ga.	Ga.	Ga.
1644	15	8.8	20	592	14.6	6	20
1604	15	7.7	20	557	14.6	7.9	20
1530	15	7.2	20	543	14.6	5.1	20
1464	15	5.8	20	304	14.6	5.6	20
1233	15	6.1	20	1314	14.5	6.1	20
1046	15	7.9	20	1097	14.5	9.4	20
1044	15	7.9	20	1081	14.5	7.9	20
674	15	9.1	20	980	14.5	5.9	20
613	15	9.3	20	937	14.5	8	20
610	15	5.6	20	757	14.5	4.9	20
425	15	7.7	20	665	14.5	6.5	20
1515	14.8	10	20	387	14.5	8.1	20
1194	14.8	8.4	20	225	14.5	5.5	20
1047	14.8	7.7	20	73	14.5	9.1	20
966	14.8	8.7	20	1625	14.3	6.5	20
745	14.8	8.3	20	876	14.3	7.7	20
662	14.8	6.2	20	850	14.3	8.3	20
569	14.8	6	20	624	14.3	7.8	20
460	14.8	6.5	20	552	14.3	4.8	20
424	14.8	6.1	20	515	14.3	8	20
290	14.8	7.6	20	437	14.3	7.3	20
118	14.8	7.9	20	278	14.3	8.7	20
1640	14.6	5.8	20	193	14.3	8.3	20
1487	14.6	6.8	20	47	14.3	7.7	20
1101	14.6	7.6	20	1620	14.1	8.6	20
1058	14.6	5.8	20	1467	14.1	5.6	20
1033	14.6	8.3	20	1411	14.1	5.8	20
741	14.6	8.6	20	1309	14.1	6	20

(Li, 2008)

The Age and Metallicity Relation of ω Centauri

145 dates over 14 billion years old.

Table 30

Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)	Age (Ga)
19	19	17.5	16	15.1
19	18.9	17.5	16	15.1
19	18.9	17.3	15.9	15.1
19	18.9	17.2	15.9	15.1
19	18.9	17.2	15.8	15
19	18.8	17.2	15.8	15
19	18.6	17.1	15.8	15
19	18.5	17.1	15.8	15
19	18.5	17	15.7	15
19	18.5	16.9	15.6	14.9
19	18.5	16.9	15.6	14.9
19	18.5	16.9	15.6	14.9
19	18.5	16.9	15.6	14.9
19	18.4	16.9	15.6	14.9
19	18.4	16.8	15.5	14.9
19	18.4	16.7	15.5	14.8
19	18.4	16.6	15.5	14.8
19	18.3	16.5	15.4	14.8
19	18.3	16.5	15.4	14.8
19	18.3	16.3	15.4	14.8

19	18.2	16.3	15.4	14.7
19	18.2	16.3	15.3	14.7
19	18	16.2	15.3	14.7
19	18	16.2	15.3	14.7
19	18	16.2	15.2	14.6
19	18	16.1	15.2	14.6
19	17.7	16.1	15.2	14.6
19	17.6	16.1	15.2	14.6
19	17.5	16.1	15.1	14.6

(Stanford, 2006)

Gyrochronology of active Kepler stars

BO-7 Ages, 52 dates over 14 billion years old. Maximum age of 199 billion years.

MH-08 Ages, 32 dates over 14 billion years old. Maximum age of 40.6 billion years.

M-09 Ages, 100 dates over 14 billion years old. Maximum age of 90 billion years.

194-billion-year age range.

Table 31

Kepler	BO-7	MH-08	M-09	Max	Min	Diff.
Star ID	Age	Age	Age	Age	Age	Age
6,311,645	199,066			199,066	199,066	0
3,545,061	80,737			80,737	80,737	0
8,008,720	72,652			72,652	72,652	0
9,958,706	68,922			68,922	68,922	0
3,116,607	37,024			37,024	37,024	0
10,288,529	36,025			36,025	36,025	0
6,033,541	35,371			35,371	35,371	0
10,131,454	30,368			30,368	30,368	0
11,869,707	27,049			27,049	27,049	0
4,265,252	26,920			26,920	26,920	0
3,232,231	25,445			25,445	25,445	0
7,026,163	25,421			25,421	25,421	0
11,512,820	25,387			25,387	25,387	0
9,047,316	24,829			24,829	24,829	0
4,477,987	23,371			23,371	23,371	0
11,234,847	23,000			23,000	23,000	0
8,196,354	22,375			22,375	22,375	0
6,949,355	21,269			21,269	21,269	0
8,151,196	17,448			17,448	17,448	0
6,611,426	17,120			17,120	17,120	0
10,140,449	16,431			16,431	16,431	0
9,001,931	33,347		89,962	89,962	33,347	56,615
9,282,684	31,138		88,300	88,300	31,138	57,162
3,853,405	42,553	40,674	77,005	77,005	40,674	36,331
11,916,978	17,927		55,024	55,024	17,927	37,097
7,895,129	25,855	28,961	53,458	53,458	25,855	27,603
7,336,648	19,137	21,704	39,106	39,106	19,137	19,969
3,447,674	15,049	19,980	34,645	34,645	15,049	19,596
8,870,709	19,034	18,814	32,893	32,893	18,814	14,079
6,263,848	15,609	17,613	31,199	31,199	15,609	15,590
12,251,466	17,584	17,729	30,998	30,998	17,584	13,414
9,270,162	20,211	18,283	29,012	29,012	18,283	10,729
7,800,319	17,168	16,772	28,715	28,715	16,772	11,943
7,672,716	11,040		27,757	27,757	11,040	16,717
11,409,072	18,634	17,096	27,505	27,505	17,096	10,409
6,138,071	12,711	15,447	26,882	26,882	12,711	14,171
12,884,530	15,928	15,709	26,793	26,793	15,709	11,084
8,559,058	15,284	15,136	25,743	25,743	15,136	10,607
8,316,269	10,599	15,079	25,136	25,136	10,599	14,537
10,658,900	15,299	14,744	24,519	24,519	14,744	9,775
7,347,192	12,429	14,077	24,452	24,452	12,429	12,023
11,507,960	17,212	15,733	24,365	24,365	15,733	8,632
11,033,253	17,490	15,887	23,491	23,491	15,887	7,604
9,006,131	13,102	13,628	23,332	23,332	13,102	10,230
10,320,616	18,406	16,818	23,139	23,139	16,818	6,321
8,282,948	17,200	15,647	22,947	22,947	15,647	7,300
9,532,000	18,105	16,533	22,902	22,902	16,533	6,369
7,676,656	17,415	15,857	22,680	22,680	15,857	6,823
9,642,973	8,337		22,194	22,194	8,337	13,857
5,514,184	17,375	15,914	22,015	22,015	15,914	6,101
11,141,099	7,265		21,724	21,724	7,265	14,459
11,410,707	16,385	14,985	21,457	21,457	14,985	6,472
10,548,635	13,533	13,074	21,344	21,344	13,074	8,270
10,874,613	16,620	15,348	20,774	20,774	15,348	5,426
8,609,986	12,871	12,610	20,722	20,722	12,610	8,112
8,947,884	12,326	12,258	20,278	20,278	12,258	8,020
5,255,317	16,431	15,375	20,011	20,011	15,375	4,636
7,603,075	10,766	11,659	19,810	19,810	10,766	9,044
10,069,421	13,836	12,890	19,681	19,681	12,890	6,791
10,622,644	16,706	16,049	19,621	19,621	16,049	3,572
6,923,582	15,602	14,460	19,596	19,596	14,460	5,136
8,172,471	7,127		19,491	19,491	7,127	12,364

9,521,504	12,588	12,096	19,336	19,336	12,096	7,240
10,355,814	7,542		19,011	19,011	7,542	11,469
3,634,449	8,513	11,014	18,497	18,497	8,513	9,984
10,594,280	10,343	10,862	18,162	18,162	10,343	7,819
3,216,636	12,229	11,630	18,121	18,121	11,630	6,491
5,179,744	13,844	12,863	17,902	17,902	12,863	5,039
7,954,835	9,280	10,418	17,589	17,589	9,280	8,309
8,743,107	6,020		17,533	17,533	6,020	11,513
7,115,878	8,219	10,426	17,505	17,505	8,219	9,286
9,452,762	6,718		17,250	17,250	6,718	10,532
9,009,059	7,797	10,302	17,144	17,144	7,797	9,347
6,203,696	5,651		17,119	17,119	5,651	11,468
6,423,596	6,186		17,031	17,031	6,186	10,845
11,751,603	14,824	14,845	16,965	16,965	14,824	2,141
9,839,974	7,037	10,503	16,863	16,863	7,037	9,826
9,142,393	12,291	11,506	16,858	16,858	11,506	5,352
8,409,813	14,274	13,845	16,831	16,831	13,845	2,986
11,497,597	11,636	11,028	16,772	16,772	11,028	5,744
12,206,862	12,632	11,794	16,737	16,737	11,794	4,943
9,385,944	14,390	14,460	16,460	16,460	14,390	2,070
11,245,201	12,228	11,443	16,448	16,448	11,443	5,005
3,649,521	12,473	11,698	16,076	16,076	11,698	4,378
4,757,567	6,406		16,039	16,039	6,406	9,633
10,087,390	5,831		15,920	15,920	5,831	10,089
4,357,396	12,422	11,675	15,877	15,877	11,675	4,202
6,192,408	10,564	10,156	15,589	15,589	10,156	5,433
6,289,713	5,104		15,586	15,586	5,104	10,482
7,428,087	12,027	11,305	15,571	15,571	11,305	4,266
7,802,832	9,452	9,613	15,568	15,568	9,452	6,116
4,543,198	10,805	10,298	15,536	15,536	10,298	5,238
11,661,734	12,508	11,911	15,391	15,391	11,911	3,480
3,122,575	5,591		15,364	15,364	5,591	9,773
10,354,861	12,475	11,886	15,338	15,338	11,886	3,452
7,812,977	5,147		15,249	15,249	5,147	10,102
7,282,564	8,505	9,201	15,230	15,230	8,505	6,725
9,723,254	8,412	9,175	15,215	15,215	8,412	6,803
9,395,387	6,649	9,323	15,179	15,179	6,649	8,530
5,612,378	6,889	9,196	15,151	15,151	6,889	8,262
6,288,106	12,147	11,536	15,118	15,118	11,536	3,582
7,673,565	5,689		14,919	14,919	5,689	9,230
9,643,189	5,690		14,896	14,896	5,690	9,206
9,784,378	11,839	11,257	14,770	14,770	11,257	3,513
4,932,500	7,580	8,835	14,724	14,724	7,580	7,144
8,045,290	9,683	9,461	14,679	14,679	9,461	5,218
11,228,805	10,664	10,103	14,661	14,661	10,103	4,558
10,320,076	10,101	9,702	14,654	14,654	9,702	4,952
5,444,950	7,446	8,776	14,621	14,621	7,446	7,175
4,358,965	6,178	9,092	14,555	14,555	6,178	8,377
12,202,127	9,237	9,202	14,545	14,545	9,202	5,343
3,860,063	12,629	12,744	14,517	14,517	12,629	1,888
10,358,432	11,393	10,800	14,484	14,484	10,800	3,684
6,716,137	11,802	11,310	14,477	14,477	11,310	3,167
3,329,839	5,032		14,457	14,457	5,032	9,425
10,266,353	4,968		14,305	14,305	4,968	9,337
9,969,806	10,942	10,352	14,302	14,302	10,352	3,950
3,647,799	10,916	10,328	14,284	14,284	10,328	3,956
7,432,523	6,430	8,730	14,276	14,276	6,430	7,846
8,154,798	11,075	10,495	14,245	14,245	10,495	3,750
11,859,917	6,860	8,483	14,064	14,064	6,860	7,204

(Reinhold, 2015)

The Gaia-ESO Survey

Table 32

EPIC	Age	Error
ID	Gyr	Gyr
K2 206432278	19.9526	4.3521
K2 206389784	19.9526	3.7172
K2 206348972	19.9526	2.6918
K2 206129788	19.9526	4.4801
K2 206010346	19.9526	1.6158
K2 206147901	19.9526	4.3432
K2 206144769	19.9526	3.8897
K2 205999925	19.9526	5.2843
K2 205944548	19.9526	4.0709
K2 206038132	19.0900	4.2473
K2 206005223	17.5481	4.4586
K2 206236189	17.0223	4.9006
K2 206066993	15.0447	3.9805
K2 206037023	14.7366	4.5605

(Worley, 2020)

185 main-sequence stars

Table 33

Name	Age (Ga.)
CD-47 1087	22.7
HD201891	21.7
HD106038	20.7
G005-040	19.5
BD-21 3420	19.2
HD 22879	18.8
HD212029A	18.8
HD 25704	18.7
CD-61 0282	18.6
HD121004	18.3
HD126681	17.5
HD184601	17.1
HD 60319	17.0
HD 17820	16.4
CD-33 3337	16.4
HD127334	15.9
HD 30649	14.5
HD110897	14.5
HD 24339	14.4
HD210752	14.0
HD174912	13.8
G088-040	13.8
HD 3567	13.7

(Chen, 2001)

Ages of Dwarfs in the Solar Neighborhood

Precise stellar ages of stars are necessary to study the evolution of the Milky Way. The age determination is significantly affected by C and O abundances of stars due to their contribution to the overall metallicity and opacity. On the basis of C and O abundances derived from high-resolution observations, we determine the ages of 148 FGK-type dwarfs in the solar neighborhood by considering C and O enhancements individually. (Chen, 2020, page 1)

We find 11 extremely old stars, which are also presented in Table 6. Seven of them have large age error ranges (age error range >4 Gyr), and six have [O/α] >0.2. All of these extremely old stars have low masses (<0.8 Mo). We have checked that these extremely old stars do not group up in any particular part of parameter space. The reason why these stars have ages older than the universe is not clear. These abnormal stars might reflect the complex formation history of the galaxy. We need more samples to study their possible origin and properties. (Chen, 2020, page 13)

Table 34

ID	Age	e	E	Age	e	E	Max	Min	Age
-	Gyr	Gyr	Gyr	Gyr	Gyr	Gyr	Age	Age	Difference
HD216259	24.50	8.15	0.83				24.50	0.83	23.67
HIP74346	22.20	4.29	0.68				22.20	0.68	21.52
BD+371458	22.10	2.15	2.43				22.10	2.15	19.95
HD24238	21.90	2.75	2.68				21.90	2.68	19.22
HD37008	21.90	2.99	2.62				21.90	2.62	19.28
HD126681	18.40	2.33	0.94	21.59	6.44	0.77	21.59	0.77	20.82
HIP91605	21.30	2.93	3.46				21.30	2.93	18.37
HD205650	18.40	1.18	1.01	19.90	0.57	0.45	19.90	0.45	19.45
HD80367	19.10	1.23	1.71				19.10	1.23	17.87
HD190404	18.40	3.55	1.96	18.91	4.97	1.18	18.91	1.18	17.73
HD4628	18.30	2.09	2.58				18.30	2.09	16.21
HTR376-001	18.10	1.25	1.84				18.10	1.25	16.85
HIP94931	17.90	1.83	2.92				17.90	1.83	16.07
HD53927	16.32	2.35	3.58				16.32	2.35	13.97
HD94028	16.30	3.24	2.81				16.30	2.81	13.49
BD+090352	15.62	1.03	0.91				15.62	0.91	14.71
BD-213420	14.50	0.70	0.74	15.56	0.65	0.69	15.56	0.65	14.91
HD116442	15.40	2.11	2.02				15.40	2.02	13.38
HD22879	12.90	0.65	0.66	15.01	1.54	1.54	15.01	0.65	14.36
HD119173	14.30	0.54	0.5	14.52	0.44	0.34	14.52	0.34	14.18
HD140283	14.42	1.28	2.96				14.42	1.28	13.14
HD45205	13.80	1.10	0.17	14.38	0.96	0.33	14.38	0.17	14.21
KIC 787153	14.30	1.12	0.95				14.30	0.95	13.35
HD199289	13.60	0.50	0.53	14.26	0.73	0.71	14.26	0.5	13.76
HD241253	13.40	0.77	0.76	14.22	0.84	0.74	14.22	0.74	13.48

The age of the Milky Way halo stars

When ignoring diffusion in the isochrones we obtained ages of 14–16 Gyr. This result is a strong argument against inhibited diffusion in old halo field stars, since it results in a serious conflict with the age of the Universe of 13.7 Gyr. The age obtained including diffusion in the isochrones was 10–12 Gyr, which agrees with the absolute age of the old globular clusters in the inner halo.

If gravitational settling is ignored in the isochrones employed (i.e. [Bergbusch & Vandenberg 1992](#)), the absolute ages obtained for the field stars can be up to 18 Gyr ([Schuster et al. 1996](#)). Similarly, [Unavane et al. \(1996\)](#) obtained ages of 15–16 Gyr for a stellar sample of [Carney et al. \(1994\)](#) using [Green et al. \(1987\)](#) isochrones. These ages conflict with the age of the Universe (13.7 Gyr, [Bennett et al. 2003](#)). Stellar evolutionary models have improved over the years not only because of considering atomic diffusion, but also better handling of opacities and α -enhanced chemical compositions.

Milky Way and M 31 globular clusters

In fact, three of the objects (B163, B393, and B398) were given “older than the Universe” ages (13.75 ± 0.11 Gyr). (**Cezario, 2013**)

Table 35

Cluster	Age
B163	16.86
MGC1	16.37
B398	16.30
B301	15.89
B393	15.71
B383	13.97
B134	13.72

(Cezario, 2013)

The ATLAS 3D Project

We also note that several objects have implied ages that are older than the canonical age of the Universe from Planck (13.74–13.82 Gyr; Planck Collaboration I). In Appendix D, we show that these points are consistent with objects close to this upper age limit considering our observational uncertainties. (**McDermid, 2015**)

75 dates

Table 36

Galaxy	Age	Galaxy	Age	Galaxy	Age
UGC08876	15.56	NGC-4472	17.70	NGC-4259	15.56
PGC-170172	17.70		16.24	NGC-4255	15.23
	14.27		17.70	NGC-4233	15.23
NGC-5846	17.70	NGC-4417	14.58	NGC-3674	17.70
	14.58		14.27		14.90
	17.32	NGC-4406	15.56		17.70
NGC-5507	15.56	NGC-4387	14.90	NGC-3665	14.58
	14.27	NGC-4379	17.70	NGC-3648	15.90
NGC-5353	14.90		15.23		14.27
NGC-5342	14.58	NGC-4377	16.95	NGC-3641	16.59
NGC-4649	17.70		14.27		15.56
	17.70		14.90	NGC-3595	17.32
	17.70	NGC-4350	14.90	NGC-3530	14.27
NGC-4623	14.90	NGC-4342	17.70	NGC-3414	14.27
NGC-4621	14.58		17.70	NGC-3379	14.27
NGC-4608	17.70		17.70	NGC-2698	15.56
	17.70	NGC-4281	14.27	NGC-2695	17.70
NGC-4570	14.27	NGC-4278	17.70		16.59
NGC-4486A	17.70		17.70		17.70
	17.70	NGC-4268	17.70	NGC-2592	17.70
	14.90	NGC-4262	14.90		17.70
NGC-4486	17.70		14.27	NGC-2577	17.70
	17.70	NGC-4261	16.24		14.58
	17.70		15.23	NGC-1121	17.70
			15.56		17.32
				NGC-0524	14.58

(McDermid, 2015)

Catalogue of masses and ages of stars

10 dates over 15 billion years

5 dates over one trillion years

58 negative dates

1,540 trillion-year age range

Table 37

Cluster	Qty	Max (Ma)	Min (Ma)	Range
a Persei	233	12,100	0.011	12,100
Collinder 185	21	1,720	-117	1,837
Coma Berenices	43	5,950	-3,820	9,770
Hogg 17	28	496	-44	540
Hyades	174	30,500,000	-296,000	30,796,000
IC 1369	87	4,190	-956	5,146
Lynga 2	64	4,100	-166	4,266
NGC-1039	46	3,650	-314	3,964
NGC-1245	701	5,630	-1,440	7,070
NGC-129	72	346	-254	600
NGC-1502	68	524	0.077	524

NGC-1805	172	702	0.000	702
NGC-188	230	7,770	-4,680	12,450
NGC-1907	40	827	111	716
NGC-1912	108	1,210	23	1,187
NGC-1960	38	271	-61	332
NGC-2099	301	4,300	-1,030	5,330
NGC-2168	413	6,880	-4,050	10,930
NGC-2264	312	1,540,000,000	-1	1,540,000,001
NGC-2391	29	2,400	-42	2,442
NGC-2422	55	5,350	-1,530	6,880
NGC-2489	81	3,280	-360	3,640
NGC-2516	72	1,660	-452	2,112
NGC-2527	37	1,530	-206	1,736
NGC-2533	87	632	-167	799
NGC-2546	111	4,750	-473	5,223
NGC-2567	62	1,530	-844	2,374
NGC-2571	88	849	-392	1,241
NGC-2581	297	3,860	0.0007	3,860
NGC-2602	126	1,320,000,000	-6	1,320,000,006
NGC-2632	104	137,000	-32,900	169,900
NGC-2682	439	30,200	-13,000	43,200
NGC-3680	87	8,070	-266	8,336
NGC-457	82	107	-101	208
NGC-4651	117	2,660	5	2,655
NGC-4665	102	599,000,000	-33	599,000,033
NGC-5138	62	1,450	-1,180	2,630
NGC-5460	47	507	-15	522
NGC-559	107	8,820	-260	9,080
NGC-5617	138	1,150	-384	1,534
NGC-581	40	176	17	159
NGC-6025	60	2,310	-124	2,434
NGC-6031	71	1,440	-702	2,142
NGC-6134	161	7,700	-2,690	10,390
NGC-6208	190	9,780	-3,960	13,740
NGC-6613	37	564	-307	871
NGC-6633	119	100,000	-7,860	107,860
NGC-6705	189	529	-117	646
NGC-6716	34	5,690	-590	6,280
NGC-6811	352	20,000	-10,100	30,100
NGC-6819	1132	6,710	-183	6,893
NGC-6866	400	16,700	-900	17,600
NGC-6939	218	1,920	-753	2,673
NGC-7039	96	3,240	-584	3,824
NGC-7062	56	860	-359	1,219
NGC-7082	126	3,580	-1,640	5,220
NGC-7092	25	1,920	-564	2,484
NGC-7209	41	1,930	-206	2,136
NGC-7243	45	733	-184	917
NGC-7380	60	175	-23	198
NGC-752	49	2,350	-1,290	3,640
NGC-7762	192	4,020	-2,240	6,260
NGC-7788	78	4,970	0.099	4,970
NGC-7790	64	607	0.021	607
Pismis 1	18	888	-434	1,322
Pleiades	99	6,690,000	-73,100	6,763,100
Stock 2	180	2,860	-352	3,212
Trumpler 22	57	426	-40	466

(Piskunov, 1980)

The Geneva-Copenhagen Survey

116 dates

Table 38

HIP Number	Age	HIP Number	Age	HIP Number	Age	HIP Number	Age
46422	17.5	107806	16.7	88351	16.1	111148	15.6
74075	17.5	18427	16.6	7539	16.0	111565	15.6
90141	17.5	64345	16.6	33690	16.0	18745	15.5
100974	17.5	65201	16.6	78609	16.0	21731	15.5
45003	17.4	68464	16.6	90261	16.0	55805	15.5
	17.4	914	16.5	3093	15.9	72045	15.5
84595	17.4	47663	16.5	7183	15.9	107821	15.5

113598	17.4	58315	16.5		15.9	22067	15.4
17472	17.3	74049	16.5	48691	15.9	27609	15.4
53822	17.3	83716	16.5	56998	15.9	32103	15.4
78640	17.3	20199	16.4		15.9	66055	15.4
91808	17.3	36654	16.4	66386	15.9	67205	15.4
101145	17.3	45514	16.4	16879	15.8	68255	15.4
107454	17.3	45749	16.4	28240	15.8	108070	15.4
25190	17.2	75269	16.4	66164	15.8	1746	15.3
31246	17.2	79276	16.4	68602	15.8	18309	15.3
91085	17.1	84062	16.4	87368	15.8	40918	15.3
48412	17.0	97125	16.4		15.8	45759	15.3
69982	17.0	104476	16.4	108065	15.8	77637	15.3
71987	17.0	9892	16.3	27246	15.7		15.3
85373	17.0	27910	16.3	62800	15.7	91860	15.3
2143	16.9	55714	16.3	65530	15.7	112113	15.3
14075	16.9	62534	16.3	72821	15.7	113989	15.3
117006	16.9	75019	16.3	73385	15.7	15799	15.2
14286	16.8		16.3	80636	15.7	24291	15.2
	16.8	81810	16.3	25880	15.6	78466	15.2
46685	16.8	39391	16.2	61517	15.6	96425	15.2
86672	16.7	62681	16.1	64499	15.6	102264	15.2
92303	16.7	79448	16.1	78163	15.6	30260	15.1

(Holmberg, 2009)

XHIP: An Extended Hipparcos Compilation

145 dates over 14 billion years

Table 39

HIP	Age	HIP	Age	HIP	Age	HIP	Age	HIP	Age
Number	Gyr	Number	Gyr	Number	Gyr	Number	Gyr	Number	Gyr
46422	17.5	18427	16.6	7539	16.0	21731	15.5	102838	15.1
74075	17.5	64345	16.6	33690	16.0	55805	15.5	117902	15.1
90141	17.5	65201	16.6	78609	16.0	72045	15.5	2941	15.0
100974	17.5	68464	16.6	90261	16.0	107821	15.5	6136	15.0
45003	17.4	914	16.5	3093	15.9	22067	15.4	40118	15.0
84595	17.4	47663	16.5	7183	15.9	27609	15.4	65383	15.0
113598	17.4	58315	16.5	48691	15.9	32103	15.4	73695	15.0
17472	17.3	74049	16.5	56998	15.9	66055	15.4	3150	14.9
53822	17.3	83716	16.5	66386	15.9	67205	15.4	58965	14.9
78640	17.3	20199	16.4	16879	15.8	68255	15.4	59315	14.9
91808	17.3	36654	16.4	28240	15.8	108070	15.4	74537	14.9
101145	17.3	45514	16.4	66164	15.8	1746	15.3	98964	14.9
107454	17.3	45749	16.4	68602	15.8	18309	15.3	100934	14.9
25190	17.2	75269	16.4	87368	15.8	40918	15.3	114743	14.9
31246	17.2	79276	16.4	108065	15.8	45759	15.3	115861	14.9
91085	17.1	84062	16.4	27246	15.7	77637	15.3	17690	14.8
48412	17.0	97125	16.4	62800	15.7	91860	15.3	18719	14.8
69982	17.0	104476	16.4	65530	15.7	112113	15.3	42741	14.8
71987	17.0	9892	16.3	72821	15.7	113989	15.3	44873	14.8
85373	17.0	27910	16.3	73385	15.7	15799	15.2	50829	14.8
2143	16.9	55714	16.3	80636	15.7	24291	15.2	66818	14.8
14075	16.9	62534	16.3	25880	15.6	78466	15.2	75676	14.8
117006	16.9	75019	16.3	61517	15.6	96425	15.2	77439	14.8
14286	16.8	81810	16.3	64499	15.6	102264	15.2	96124	14.8
46685	16.8	39391	16.2	78163	15.6	30260	15.1	114346	14.8
86672	16.7	62681	16.1	111148	15.6	48661	15.1	6485	14.7
92303	16.7	79448	16.1	111565	15.6	51901	15.1	20677	14.7
107806	16.7	88351	16.1	18745	15.5	66817	15.1	20924	14.7

(Anderson, 2012)

Conclusion

The star CS31082-001 has an age between 10 to 14 billion years old. (Cayrel, 2001, Page 692)

For these abundance ratios and our production ratio (Th/U)₀= 1.557, the ages for the two halo stars CS 31082_001 and BD +173248 are, respectively, 16.2 and 14.9 Ga, both having uncertainties of approximately 3.5 Ga arising from observational uncertainties. (Kratz, 2007, Page 50)

Comparing these predicted ratios with the weighted mean M15 value given above leads to age estimates ranging from 13.2 to 15.8 Ga, with an average value of 14.3 Ga. The age estimates resulting from the theoretical predictions have an uncertainty on the order of 3 Ga. (Sneden, 2000a, Page 88)

From the observed Th abundance, an average age of 16 Ga is derived for CS 228922052, consistent with the lower age limit of 11 Ga derived from the upper limit on the U abundance. (Sneden, 2000b, Page 139)

Comparing these initial values with the observed stellar ratio yields values of 13.7, 15.7, and 13.1 Ga, with an average age for HD 115444 of 14.2 Ga. (Westin, 2000, Page 798)

Table 40

Reference	Max (B.Y.)	Min (B.Y.)	Difference
-----------	------------	------------	------------

(Albrecht, 2012)	339,601,816	13	339,601,803
(Barnes, 2007)	20	0.164	20
(Brown, 2014)	28.84	3.15	26
(Cowan, 1997)	16.8	13.5	3
(Cowan, 1999)	41	10.2	31
(Cowan, 2002)	21.7	8.2	14
(CSIRO, 2015)	113	-219	332
(Freire, 2001)	1,873	-31,379	33,252
(Freire, 2015)	67,524	-106,470	173,994
(Goriely, 2001)	22.6	1.71	21
(Hayek, 2009)	36.5	-7.3	44
(Johnson, 2001)	22.5	3	20
(Kiziltan, 2010)	55.71	0.75	55
(Krauss, 2003)	20	15.4	5
(Li, 2008)	20	20	0
(Ludwig, 2010)	37.2	-1.5	39
(Maxted, 2015)	10,000,000,000	0.17	10,000,000,000
(Mello, 2014)	55.57	-9.81	65
(Reinhold, 2015)	200	200	0
(Rocha-Pinto, 2002)	18.9	0.28	19
(Roederer, 2009)	20.4	-4.4	25
(Schatz, 2002)	50	-10	60
(Snedden, 2003)	19.3	10.4	9
(Stanford, 2006)	19	19	0
(Wanajo, 2002)	57.52	-118.21	176
(Wanajo, 2003)	23.37	-2.5	26
(Worley, 2020)	20	20	0
Totals	10,000,000,000	-106,470	10,000,106,470

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