The Joint Institute for Nuclear Astrophysics

Development of the JINA Metal-Poor Star Elemental Abundance Database

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Abstract

Metal-poor stars are objects with overall abundances of their heavy elements, such as iron, that are less than 10% that of the Sun. The lowest metallicity stars approach deficiencies of almost 1/500,000 of the solar value, and are thought to have been born in the early Galaxy, shortly after the Big Bang. They provide our best contemporary probe of the chemistry of the early Universe, and highly constrain the origin of the elements. Given the large expansion of the dataset of metal-poor stars in recent years, there is a need to compare and contrast values obtained by from different researchers without an exhaustive literature search. This project continues the work of an REU summer project in which a database of parameters of metal-poor stars was initially developed.

Currently there has been further development, as additional parameters have been added, as well as an expanded data set. This database, which is now sponsored by JINA, the Joint Institute for Nuclear Astrophysics, in which MSU is a partner, will be useful to those who wish to compare values of metallicity, elemental abundances, and additional stellar parameters that are required for the interpretation of the astrophysical origins of metal-poor stars and studies of galactic chemical evolution.

Resources

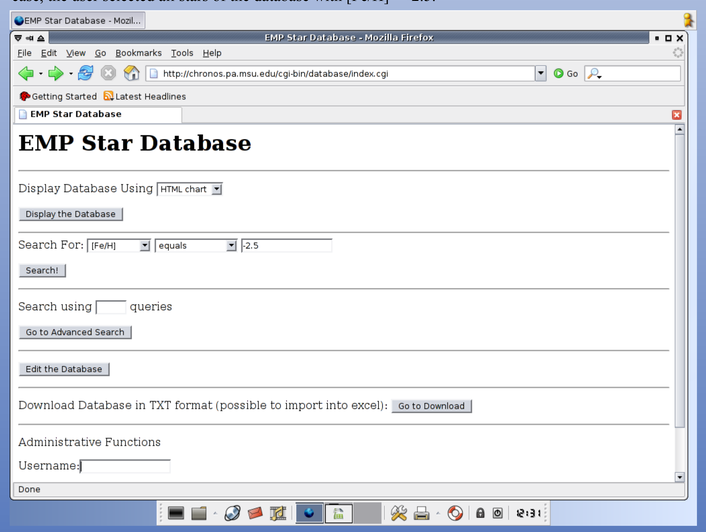
•Provides a web-based interface access to a large set of data from many sources without the need for an extensive literature search

•Specialists and non-specialists alike have access to data and the ability to screen for certain types of stars without needing to go find an expert

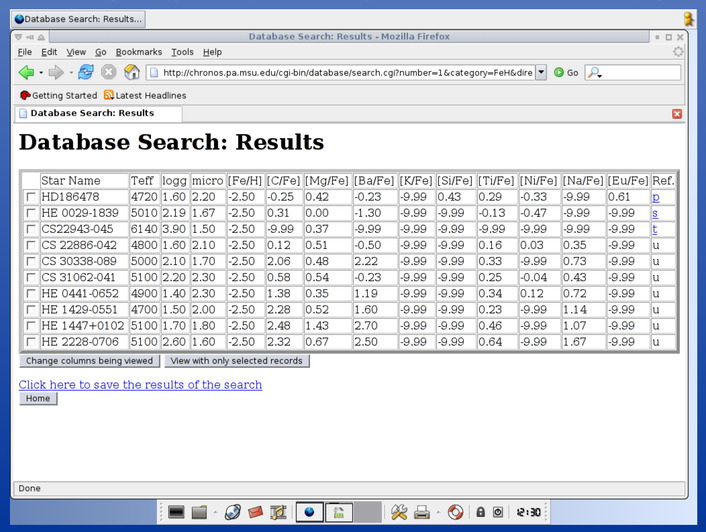
•Allows for the comparison of stellar parameters and chemical abundances through a web-based interface that is available to all

•The temperature scale, as well as other parameters, such as the adopted reference solar abundances, can be varied with a corresponding change in the listed elemental abundances

The web based interface allows for users to select only a portion of the database to display. In this case, the user selected all stars of the database with [Fe/H] = -2.5.



Displayed below are the results of the query. Note that values of -9.99 are missing values (the element was not measured by the study referenced). There are many more elements measured per star not displayed.



Star Name	Teff	logg	micro	[Fe/H]	[C/Fe]	[Mg/Fe]	[Ba/Fe]	[K/Fe]	[Si/Fe]	[Ti/Fe]	[Ni/Fe]	[Na/Fe]	[Eu/Fe]	Ref.
HD186478	4720	1.60	2.20	-2.50	-0.25	0.42	-0.23	-9.99	0.43	0.29	-0.33	-9.99	0.61	p
HE 0029-1839	5010	2.19	1.67	-2.50	0.31	0.00	-1.30	-9.99	-9.99	-0.13	-0.47	-9.99	-9.99	s
CS22943-045	6140	3.90	1.50	-2.50	-9.99	0.37	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	t
CS 22886-042	4800	1.60	2.10	-2.50	0.12	0.51	-0.50	-9.99	-9.99	0.16	0.03	0.35	-9.99	u
CS 30338-089	5000	2.10	1.70	-2.50	2.06	0.48	2.22	-9.99	-9.99	0.33	-9.99	0.73	-9.99	u
CS 31062-041	5100	2.20	2.30	-2.50	0.58	0.54	-0.23	-9.99	-9.99	0.25	-0.04	0.43	-9.99	u
HE 0441-0652	4900	1.40	2.30	-2.50	1.38	0.35	1.19	-9.99	-9.99	0.34	0.12	0.72	-9.99	u
HE 1429-0551	4700	1.50	2.00	-2.50	2.28	0.52	1.60	-9.99	-9.99	0.23	-9.99	1.14	-9.99	u
HE 1447+0102	5100	1.70	1.80	-2.50	2.48	1.43	2.70	-9.99	-9.99	0.46	-9.99	1.07	-9.99	u
HE 2228-0706	5100	2.60	1.60	-2.50	2.32	0.67	2.50	-9.99	-9.99	0.64	-9.99	1.67	-9.99	u

Background

The oldest stars formed out of the primordial material produced by the Big Bang. These materials included only hydrogen, helium, and trace amounts of lithium, meaning that the oldest stars were essentially metal-free. These massive stars ended their lives in supernova outbursts, enriching the interstellar medium with metals they had created through nucleosynthesis in their cores, and metals that had been produced via explosion. These stars are called Population III stars by astronomers. The gas which they polluted with their elements formed the next generations of stars, known as Population II stars; these are the sorts of objects that populate the metal-poor star database. These Population II stars are considered to be "metal-poor" because their spectra reveal weak metallic lines. From these stars, one is able to infer details of the nature of the Population III stars and, in effect, conduct cosmology through stellar chemistry.

Development

•Database is still being populated, the expected total numbers of stars will be on the order of 2500. Thus far, it includes:

- •20 papers
- •447 stars
- •Links to all web-available references

•Parameters included are

- •Iron to Hydrogen ratio ([Fe/H])
- •Effective temperature (Teff)
- •Surface gravity (log g)
- •Carbon to iron ratio ([C/Fe])
- •Abundances of s-process and r-process elements such as Ba and Eu, as well as many other abundances.

•Allows the user to search by parameter and select which entries to display

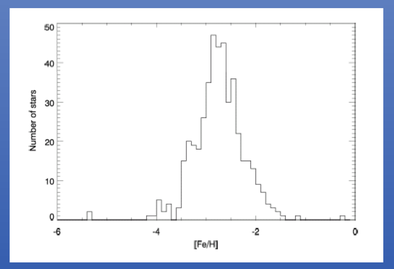
•A text file of the database can be downloaded from the site

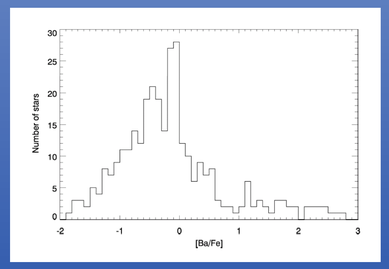
Sub-populations of the database

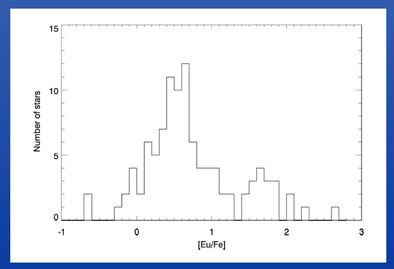
Beyond being indicators of age, metal-poor stars form the basis for some of the most interesting science coming out of astrophysics today. Included in this database are stars that exhibit significant carbon, r-process, and s-process enhancements, relative to the solar values, of these ratios. The chemical signature of these stars hold the history of the very first stars from which these were created. Barium serves as an indicator of s-process enhancement and europium of r-process.

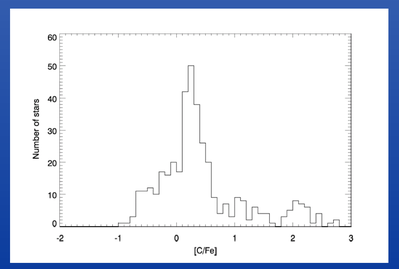
This database currently gives the user the ability to select for these effects and to use this data to further the nuclear astrophysics research that is being conducted at MSU and worldwide.

Below are shown the distributions of the metallicities of the stars, s-process enhancement, r-process enhancement and carbon enhancement in the present database.









Referenced Papers Currently in the Database

Aoki, W., Beers, T.C., Christlieb, N., Norris, J.E., Ryan, S.G., & Tsangarides S. 2006, "Carbon enhanced metal-poor stars. I. Chemical composition of 26 stars," in preparation

Aoki, W., Ando, H., Honda, S., Iye, M., Izumiura, H., Kajino, T. et al. 2002, "Chemical composition of carbon-rich, very metal-poor subgiant LP625-44 observed with the Subaru/HDS," Publ. Astron. Soc. Japan, 54, 427

Aoki, W., Ryan, S.G., Norris, J.E., Beers, T.C., Ando, H., Iwamoto, N. et al. 2001, "Neutron Capture Elements in s-Process-Rich, Very Metal-Poor Stars," ApJ, 561, 346

Aoki, W., Norris, J.E., Ryan, S.G., Beers, T.C., & Ando, H. 2000, "Detection of Lead in the Carbon-rich, Very Metal-poor Star LP 625-44: A Strong Constraint on S-Process Nucleosynthesis at Low Metallicity," ApJL, 536, 97

Aoki, W., Norris, J.E., Ryan, S.G, Beers, T.C., & Ando, H. 2002, "The Chemical Composition of Carbon-rich, Very Metal Poor Stars: A New Class of Mildly Carbon Rich Objects without Excess of Neutron-Capture Elements," ApJ, 567 ,1166

Arnone, E., Ryan, S. G., Argast, D., Norris, J. E., & Beers, T. C. 2005, "Mg abundances in metal-poor halo stars as a tracer of early Galactic mixing," A&A, 430, 507

Barklem, P. S., Christlieb, N., Beers, T. C., Hill, V., Bessell, M. S., Holmberg, J. et al. 2005, "The Hamburg/ESO R-process enhanced star survey (HERES). II. Spectroscopic analysis of the survey sample," A&A, 439, 129

Bonifacio, P., Molaro, P., Beers, T. C., & Vladilo, G. 1998, "CS 22957-027: a carbon-rich extremely-metal-poor star," A&A, 332, 672

Carretta, E., Gratton, R., Cohen, J.G., Beers, T.C., & Christlieb, N. 2002, "Stellar Archaeology: a Keck Pilot Program on Extremely Metal-Poor Stars from the Hamburg/ESO Survey. II. Abundance Analysis," AJ, 124, 481

Cayrel , R., Depagne, E., Spite, M., Hill, V., Spite, F., Francois, P. et al. 2004, "First stars V – Abundance patterns from C to Zn and supernova yields in the early Galaxy," A&A, 416, 1117

Depagne, E., Hill, V., Spite, M., Spite, F., Plez, B., Beers, T.C. et al. 2002, "First Stars II. Elemental abundances in the extremely metal-poor star CS 22949-037: A diagnostic of early massive supernovae," A & A, 390, 187

Hill, V., Barbuy, B., Spite, M., Spite, F., Cayrel, R., Plez, B. et al. 2000, "Heavy-element abundances in the CH/CN-strong very metal-poor stars CS 22948-27 and CS 29497-34," A & A, 353, 557

Honda, S., Aoki, W., Kajino, T., Ando, H., Beers, T.C., Izumiura, H. et al. 2004, "Spectroscopic Studies of Extremely Metal-Poor Stars with the Subaru High Dispersion Spectrograph. II. The r-Process Elements, Including Thorium," ApJ, 607, 474

McWilliam, A., Preston, G.W., Sneden, C., & Searle, L. 1995, "Spectroscopic Analysis of 33 of the Most Metal Poor Stars. II," AJ, 109, 2757

Norris, J.E., Ryan, S.G., & Beers, T.C. 1997, "Extremely Metal-Poor Stars. The Carbon-Rich, Neutron Capture Element-Poor Object CS 22957-027," ApJ, 498, 2

Norris, J.E., Ryan, S.G., & Beers, T.C. 1997, "Extremely Metal-poor Stars. IV. The Carbon-rich Objects," ApJ, 488, 350

Preston, G.W. & Sneden, C., 2001, "The Incidence of Binaries among Very Metal-poor Carbon Stars," AJ, 122, 1545

Ryan, S.G., Norris, J.E., & Beers, T.C. 1996, "Extremely Metal-poor Stars. II. Elemental Abundances and the Early Chemical Enrichment of the Galaxy," ApJ, 471, 254

Summary

The ability to access data easily is essential to the creation of this database. This aims to remove the need for lengthy literature searches and the need for an expert to compile information of interesting stars that a scientist in a related field might study.

The idea of gathering data together is not a new one. There are many incarnations of databases throughout all of science. What sets this database apart is the uniqueness of its dataset and what it aims to do: provide a way to compare stellar parameters and chemical abundances of the metal-poor stars that will be used to reveal details of the evolution of the elements in the Universe.

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