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Study of Dergaon Meteorite:Possible Relics of s-procss Nucleosynthesis

Pratima Dutta[1]**, and Kalpana Duorah**[2]

1Dept. Of Physics, Dimoria College, Khetri,782403, India
2Department of Physics, Gauhati University, Guwahati-781014, India

E-mail: pratima_dutta2005@yahoo.com

Abstract. The Dergaon meteorite was collected in 2001 from Dergaon, Assam, India. It is classified as H5 chondrite.Elemental abundance ratios are obtained in an analysis done by[1].Here ^{129}Xe which should be ubiquitous in meteorite is not reported, while rests of Xe isotope are there. We have taken the abundance of isotope in the proportion of universal ratio. This comes^{129}Xe=98.58 when ^{132}Xe=100.The whole^{129}Xe might be due to in decay^{129}I in sample. The time interval between formation of solar system and formation of meteorite is indeed crucial in that time when meteorite material becomes a closed system with no nuclear process; only beta decay can take place. In this paper we are trying to study only s-process nucleosynthesis in xenon to study the meteorite.

1. Introduction

On March 2, 2001 at about 16.40 local time a multiple fall of stony meteorite occurred in the eastern region, near a town Dergaon of state Assam ($26^0 42' N$,$93^0 51' E$)in India. The largest fragment weighing 10.2kg was recovered in the village Balidua, a few kilometers west of Dergaon. Megascopic observation shows the meteorite is hard and measuring 17cm along its longest axis. It is brownish black in colour and shows a black streak. The meteorite has a thin fusion crust devoid of any distinctive surface features. Preliminary mineralogic and petrographic studies shows that meteorite belongs to H5 group[2]. The elemental abundance ratios are obtained in an analysis done by[1]. From this analysis shows the presence of higher element as well as presence of noble gas element.Experimentally observed radioisotope that also present in Dergaon meteorite are ^{48}V, ^{7}Be, ^{58}Co, ^{56}Co, ^{46}Sc, ^{57}Co,^{54}Mn,^{22}Na, ^{60}Co, ^{26}Al and ^{40}K. In case of heavy element and their isotope they are considered to be product of a variety of nucleosynthetic processes occurring in stars [3,4]. Experimental evidence for the reality of two of proposed processes, the neutron capture on a slow time scale(s-process) and on a rapid time scale(r-process), comes from the investigation of the meteorite. So in this paper we are trying to find out mainly s-process element that is present in Dergaon meteorite. Here mainly we are focusing on the noble gas element Xenon as meteoritic Xenon is an important tracer of extinct radio nuclides abundance.

2. Mathematical Formulation For s-process

Each nucleus in the chain is created or destroyed by neutron capture and/or weak decays. In case where decay is either too fast or too slow for competition they can eliminate from the chain or ignored, respectively. The resulting set of equation for uniquely defined chain is then the one

Table 1. Isotropic Composition and Content [$\times 10^{-12}$ cc STP/gm] in the sample of Dergaon meteorite.The isotopic composition if normalized to^{132}Xe= 100

$Xenon$	^{132}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{134}Xe	^{136}Xe
$DergaonM$	265.5	–	–	16.48±0.06	82.33 ± 0.24	37.85 ± 0.06	31.84 ± 0.10

Table 2. Comparison of abundance ratios of Dergaon meteorite with average Xe in chondrite and solar abundance

$Xenon$	$DergaonMeteorite$	Average Xe in Chondrite	$Solar$
$^{128}Xe/^{132}Xe$	–	0.08	0.08
$^{129}Xe/^{132}Xe$	–	1.02	1.05
$^{130}Xe/^{132}Xe$	0.06	0.15	0.16
$^{131}Xe/^{132}Xe$	0.31	0.815	0.82
$^{134}Xe/^{132}Xe$	0.14	0.38	0.39
$^{136}Xe/^{132}Xe$	0.11	0.32	0.32

solved by CFHZ [5].

$$\frac{dN_A}{dt} = < \sigma v >_{A-1} n_n(t) N_{A-1} - < \sigma v >_A n_n(t) N_A \tag{1}$$

whereN_A(t) is the abundance of unique isobar of atomic weight A on the s-process path. The time dependence enters explicitly through the free neutron density n_n(t) and through the temperature dependence of $< \sigma v >$. Considering for this purpose the Te, I, Xe portion of the nuclear chart as in fig1. Here assuming that s-process chain flows through ^{126}Te and branches due to competition between neutrons capture and beta decay.

The branching at ^{127}Te and^{128}I are comparably weak since only small part of the S-process flow is bypassing ^{128}Xe.Therefore, the product of the stellar cross section and respective S-abundance is slightly smaller for ^{128}Xe than for ^{130}Xe. The second branching at ^{128}I with half life 25 mins is exceptional, since it is originate from the competition between short lived decay and electron capture (EC) decays only. In contrast to other branching eliminate an important uncertainty in the s- process calculation of the isotopic Xe abundance.

3. Experimental Result And Observation

The observed experimental result for Xe obtained from the sample of Dergaon meteorite carried out at extraction system of VG-100 noble gas mass spectrometer is summarized in table1 (Source P.N.Shukla et al Meteoritics and Planetary Science Vol 40, No.4 pp631).

From above experimentally found data it gives that^{129}Xe which should be ubiquitous in meteorite is not experimentally found in Dergaon meteorite. Out of nine isotopic of Xenon only five is present in Dergaon meteorite. This isotopic ratio is compared with average trapped Xe in Chondrite and solar abundance.

From Table 2 it is clear that ^{130}Xe in Dergaon meteorite which is produced mainly in s-process in accordance with the observed value. However ^{128}Xe is totally absent in Dergaon meteorite. Whereas the rest of Xe isotope are also in accordance with observed Xenon in chondrite and in solar abundance.

4. Conclusion

Although s-process is best understood of nucleosynthesis in stars, however various details, including exact location and neutron source, have remained uncertain. One possible explanation for their origin was to assume local supernovae, which triggered the collapse of a protosolar cloud to form a star and also produce heavy element and their isotope. Some isotopic anomalies were found in some meteorite.However this interpretation is questioned by[5] who pointed out that anomalies need not be the result of local event. Instead presolar grains could have formed much earlier and could have been ingested by presolar cloud. Such a model of course would deny any chronological information w.r.t solar system, but would rather yield information on the time scale for condensation of supernovae eject. One of the most favourable site s-process is thermally unstably burning He shell of intermediate- mass rad giant stars on the AGB[6,7]. In case of Dergaon meteorite, it is observed that only s-^{130}Xe is present whereas s-^{128} Xe is not experimentally determinedin the sample. Whether the range of conditions typical for the processes that contributed to solar system s-material was different is an interesting but open question at this time. For an answer, it will be necessary to identify s-process contribution to other element in the same phases.

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