THE ASTROPHYSICAL JOURNAL, 178:L9–L10, 1972 November 15


# URANIUM IN THE SPECTRUM OF HR 465

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*Received 1972 August 25*

## ABSTRACT

Uranium has been identified in the 1960–1961 spectrum of HR 465 at a confidence level of 3.8 $\sigma$ (one chance in $10^4$ of fortuitous occurrence). The uranium abundance is about a million times the solar-system value. This should be compared to the abundances of the lanthanides, for which M. Aller finds excesses $\leqq 10^5$.

Hartoog and Cowley (1972) announced the identification of singly ionized uranium in the 1960–1961 spectrum of HR 465. The general method of line identifications used was that presented by them, and will be discussed at length in a later paper. Our current identification is based on the results of a comparison of stellar wavelength coincidences with 32 laboratory and 10,000 sets of 32 nonsense wavelengths, generated with the aid of a random-number routine. In only one of these 10,000 trials was the number of coincidences equal to the "on wavelength" stellar coincidences.

The current Monte Carlo method seems free of the shortcomings of the Russell-Bowen procedure resulting from nonrandom line separations, and it seems appropriate to assign to the uranium identification a confidence level of 3.8 $\sigma$ (a one in $10^4$ chance of a random occurrence). The traditional signs of an identification, involving the presence of the strongest lines, etc., are also positive.

We have made a determination of the abundance of uranium relative to the lanthanides cerium, neodymium, samarium, and gadolinium. The principal uncertainty is the second ionization potential of uranium which is given by Radziemski *et al.* (1970) as 10.6 ± 1 eV. At the adopted temperature of HR 465 ($T \approx 10^4$ ° K) this gives rise to an uncertainty of ±0.5 dex in the abundance ratios. The partition function for $U^{++}$ is also unknown, but the uncertainty here is less important.

The method adopted to determine the abundance is a straightforward differential procedure based on an intercomparison of lines of similar intensities. We have used mean physical conditions from an atmospheric model ($T \approx 10^4$ ° K, $\log P_e = 2.5$). All of the lines involved are of less than 1 eV excitation potential, and for this reason the Corliss-Bozman 1962) $gf$-values should be reliable. The results are summarized in table 1. Column (3) gives the logarithm of the abundance of uranium relative to the element from whose spectrum the comparison line was chosen. The last column gives the uranium to hydrogen ratio in HR 465, adjusted to the usual scale of log H = 12.00. These figures were computed using the data given in Table 5 of Aller (1972).

These results are uncertain to about one order of magnitude. Nevertheless, there is a clear indication that uranium is enormously overabundant in the 1960–1961 spectrum of HR 465 compared to solar system values (cf. Urey 1967). According to Aller (1972), the lanthanides show overabundances ranging up to $10^5$. For uranium, the corresponding factor is about $10^6$.

The implications of these results for theories of nucleosynthesis are considerable, but they will not be discussed here. We have run significance tests for a number of other actinides, but none have given $\geqslant 2$ $\sigma$ results.

We wish to thank Drs. W. P. Bidelman and Margo F. Aller for generously giving us permission to make use of their material on HR 465.

TABLE 1

URANIUM ABUNDANCE IN HR 465

| Uranium Line | Comparison Line | log(U/El) | log(U) (log H = 12.0) |
|---|---|---|---|
| 3859.58 | Nd II 3869.07 | −0.7 | 5.3 |
| 3859.58 | Sm II 3857.91 | −0.7 | 5.3 |
| 3859.58 | Gd II 3850.97 | +1.0 | 6.1 |
| 4050.04 | Sm II 4042.90 | 0.0 | 6.0 |
| 4090.14 | Ce II 4085.23 | +0.4 | 5.6 |
| 4090.14 | Ce II 4087.36 | +0.1 | 5.3 |
| 4090.14 | Ce II 4088.85 | +0.2 | 5.4 |

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