3.5 field stars with m_{pg} < 14.5 mag. within an area with radius 3.6 arcmin., so it is unlikely that these variable stars all belong to the field. Furthermore, the star G 327 (V = 13.28, B-V = 0.35; ref. 5) is also located at the blue side of the HB, and at least 5 unpublished, similar stars are waiting for checking.

A provisional conclusion is that these stars may form a new group. For the time being we call them "RRe" and maybe they should be divided into two: one on the blue side and the other on the red side of the classical boundaries of the instability strip.

(c) A Variable Star at the HB/RGB Intersection

G 543 = Alcaíno 376 = Lee 4507 has a nearby faint star separated by 4.2 pixels (1.9 arcsec) with brightness difference about 3.6 mag. The influence of the faint star is ≤ 0.01 mag., but the influence varies with seeing and guiding. The light curve is complicated and the time interval is not long enough for it to be analysed. This would be the first known variable at the intersection of the HB and RGB.

I hope that these results, albeit provisional, will stimulate similar research in other places and that more astronomers will become interested in pointing their large telescopes at globular clusters in the future.

Acknowledgements

I am grateful to ESO for letting me use its advanced computer and MIDAS system and also for the financial support. I also thank Drs. Ortolani and Aurière for help in running DAOPHOT.

References

(1) Greenstein, J.L., 1939, *Ap. J.* **90,** 387.
(2) Alcaíno, G., 1975, *Astron. & Astrophys. Suppl.* **21,** 1.
(3) Lee, S.W., 1977, *Astron. & Astrophys. Suppl.* **27,** 367.
(4) Norris, J., 1981, *Ap. J.* **248,** 177.
(5) Publ. of the Beijing Astr. Obs., 1979, No. 4.
(6) Yao Bao-an, 1986, *Astrophys. and Space Science,* **119,** 41.

Neutron Density and Neutron Source Determination in Barium Stars

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Introduction

The origin of the large s-process enhancements observed in the classical Barium (Ba II) stars (Lambert 1985) remains one of the most fundamental challenges in stellar nucleosynthesis theory. An understanding of this phenomenon would lead to an improvement in our knowledge of both s-process systematics, and mixing processes occurring during the late phases of stellar evolution. A determination of two crucial aspects of the s-process site, namely the neutron source and the neutron density, would be a significant advance towards this goal. Knowledge of these two parameters would allow strong constraints to be placed on any evolutionary hypothesis purporting to explain the Ba II star phenomenon. Hitherto, the neutron source has been analysed in only two Ba II stars, and the neutron density also in only two.

In order to extend such studies to other members of this important stellar class, spectroscopic observations of a large number of both northern and southern hemisphere Ba II stars were obtained. This work was carried out in collaboration with D.L. Lambert at the University of Texas, Austin. In this paper, which reports the first results of our survey, we discuss the determination of the neutron source and neutron density in the cool (K4) Ba II star HD 178717, and compare our results with the abundances predicted if mass transfer from an evolved asymptotic giant branch (AGB) star has occurred. This scenario for the origin of the s-process enhancements in Ba II stars has received a great deal of theoretical and observational attention in recent years (see Malaney 1987).

Observations of Neutron Indicators

The two most likely neutron producing reactions in a stellar interior are the $^{13}C(\alpha, n)^{16}O$ and the $^{22}Ne(\alpha, n)^{25}Mg$ reactions. It is well known that the operation of the $^{22}Ne(\alpha, n)^{25}Mg$ neutron source should lead to an observable distortion in the relative abundances of the magnesium isotopes from their solar system distribution of $^{24}Mg : ^{25}Mg : ^{26}Mg$ = 79 : 10 : 11. In order to obtain information on the source of neutrons, the magnesium isotopic mixture in HD 178717 was determined from observations of the molecular MgH (0,0) band lines at 5101 Å and 5107 Å. The MgH lines at 5101 Å have the advantage of a large isotopic splitting (~0.14 Å). Contamination by lines from the C_2(0,0) and C_2(1,1) bands, however, leads to significant blending in this spectral region. Although the MgH lines at 5107 Å have the disadvantage of a smaller separation (~0.1 Å), the ^{25}MgH and ^{26}MgH lines are unaffected by C_2 blends. In addition, since the observed rubidium abundance is known to be an indicator of the neutron density at the s-process site, the abundance of this element in HD 178717 was determined from observations of the Rb I line at 7800 Å. In order to minimize non-LTE effects, this rubidium abundance determination was carried out differentially with respect to the standard K3 giant μ Aql.

The observations discussed here were obtained in April 1987 at the ESO La Silla observatory using the Reticon-equipped echelle spectrometer of the 1.4-m Coudé Auxiliary Telescope. The length and the resolution of the spectra were 40 Å and 0.05 Å, respectively, for the 5100 Å centred spectrum, and 60 Å and 0.08 Å, respectively, for the 7800 Å centred spectra. The signal-to-noise ratio in the continuum exceeded 100 in all of the obtained spectra. The raw data were reduced at Caltech using the spectral reduction package FIGARO.

In order to determine the magnesium isotopic distribution and the rubidium abundance of our stars, the observed spectra were compared with synthetic spectra calculated using an LTE spectral synthesis programme (Sneden 1974; assistance in the use of this code was provided by A. McWilliam). The required input for the synthesis programme, namely the parameters of the observed lines and atmospheric parameters of the observed stars had previously been determined. To allow a proper comparison of the theoretical and observed spectra, a composite of the rotational, macroturbulent and instru-

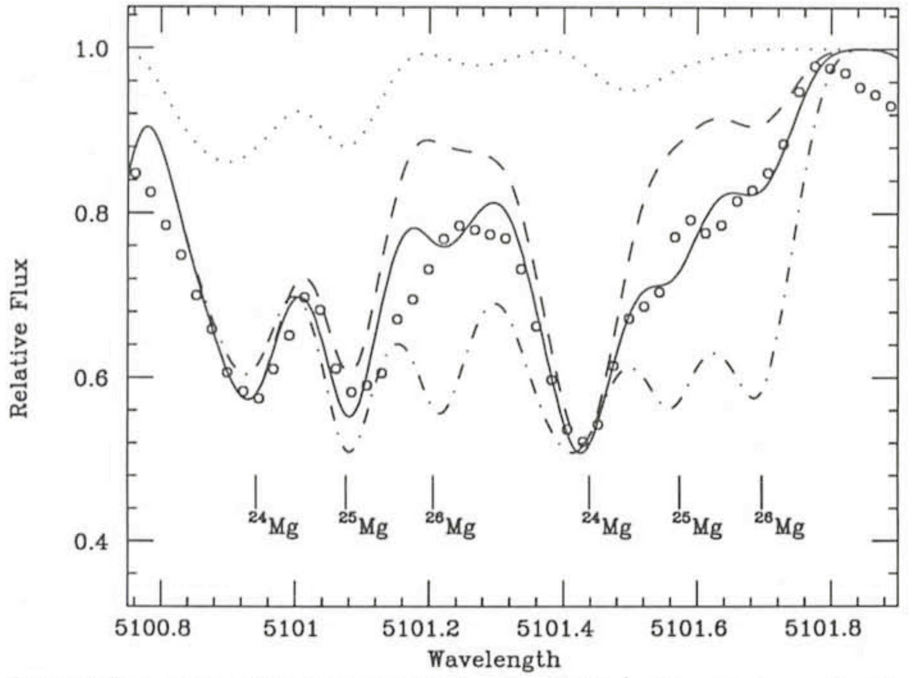

Figure 1: *Comparison of the observed MgH feature at 5101 Å with synthetic spectra. The synthetic spectra are calculated assuming a C_2 contribution alone (dotted curve); a solar distribution of magnesium isotopes (dashed curve); a best fit distribution of magnesium isotopes where ^{24}Mg : ^{25}Mg : ^{26}Mg = 60 : 25 : 15 (solid curve); and an equal distribution of magnesium isotopes (dot-dashed curve). The circles represent the observed data points. The principal lines of the spectrum are indicated.*

mental broadening was applied to the synthetic spectra.

Figure 1 displays a comparison of the observed MgH spectra of HD 178717 in the 5101 Å region with synthetic spectra calculated for different distributions of the magnesium isotopes. The strength of C_2 was estimated by fitting the profile of the C_2 line at 5086 Å. The calculation with the magnesium isotopes in the ratio ^{24}Mg : ^{25}Mg : ^{26}Mg = 60 : 25 : 15 clearly gives the best fit to the observed data. The fact that this fit is not exact could be the result of a number of error sources, such as poor fitting of the continuum, poorly determined gf values or stellar parameters, a poor determination of the C_2 strength, or the presence of unknown blends. The latter source of error is the most likely in view of the cool nature of the star under study. In light of these uncertainties it is important to check these results using another portion of the stellar spectrum. Figure 2 shows the observed and synthetic spectra in the region of the MgH lines at 5107 Å. It can be seen that a good fit is obtained for a magnesium isotopic mixture of ^{24}Mg : ^{25}Mg : ^{26}Mg = 56 : 22 : 22, which is very similar to that used in the best fit of the 5101 Å region. We would tend to give somewhat less weight to this distribution due to the presence of an unidentified line (indicated by a ? in Figure 2) blended between the ^{25}Mg and ^{26}Mg lines. However, the good agreement of the results obtained from the different MgH features, gives us a high degree of confidence that HD 178717 does indeed possess an excess of ^{25}Mg and ^{26}Mg relative to the solar distribution of the magnesium isotopes.

Only two lines of atomic rubidium are accessible in the visible spectrum. These are the neutral Rb I lines at 7800 Å and 7948 Å. The 7800 Å line was chosen for analysis since the 7948 Å line is blended with an unidentified line. Figure 3 displays the observed Rb I line at 7800 Å in HD 178717, and in the comparison star μ Aql. Shown in each spectrum is the best fit synthetic spectrum computed for each star. A nearby Fe I line at 7802.5 Å was used in order to determine the Rb/Fe ratio in each star. Using the notation [Rb/Fe] = log (Rb/Fe)$_{\mathrm{BaII}}$ – log(Rb/Fe)$_{\mu\mathrm{Aql}}$, we find [Rb/Fe] equal to +0.2 in HD 178717. Knowing the dilution factor of the irradiated material, the Rb/Fe ratio of the irradiated material can then be estimated in a simple manner.

AGB Stars

Calculations of AGB models for core masses in which the ^{22}Ne(α, n)^{25}Mg neutron source is assumed to operate, show that the relative abundance of ^{25}Mg and ^{26}Mg should be at least equal to the ^{24}Mg abundance. For example, calculations for an AGB model possessing a core mass of 1.16 $M_\odot$ predict an observed ^{26}Mg/^{24}Mg ratio of ~3 (Malaney 1987). From Figures 1 and 2 where calculations of synthetic spectra assuming an equal distribution of the magnesium isotopes are shown, it is clear that such a distribution of isotopes results in a very poor representation of the observed data. Even taking into account uncertainties in both the calculations and the observations, this large discrepancy leads us to the conclusion that mass transfer from an evolved intermediate-mass AGB star is not responsible for the s-process enhancements observed in HD 178717.

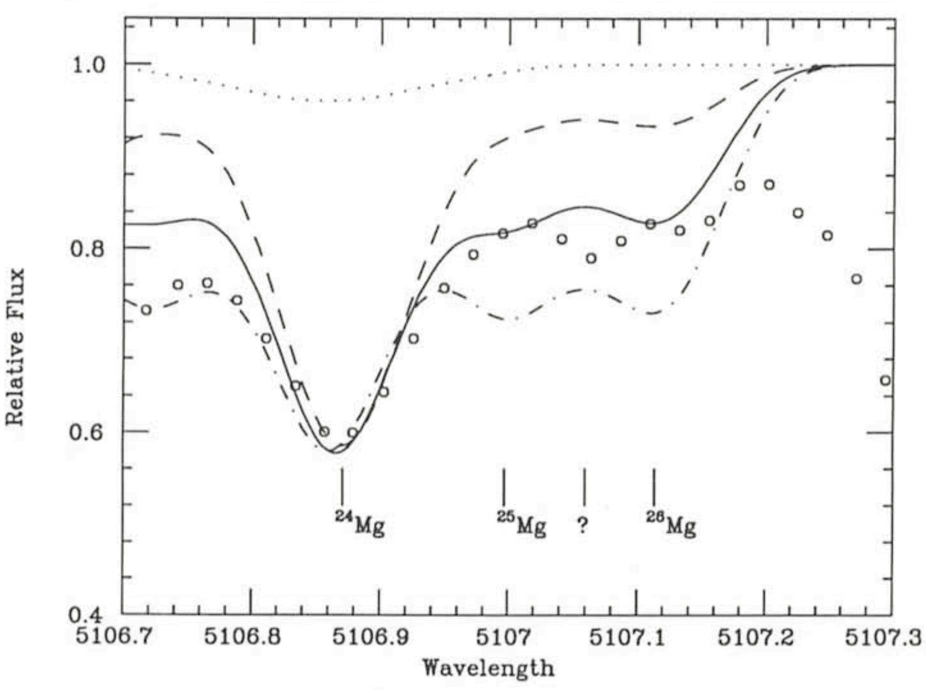

Figure 2: *As in Figure 1 except the best fit for the 5107 Å MgH feature is ^{24}Mg : ^{25}Mg : ^{26}Mg = 56 : 22 : 22.*

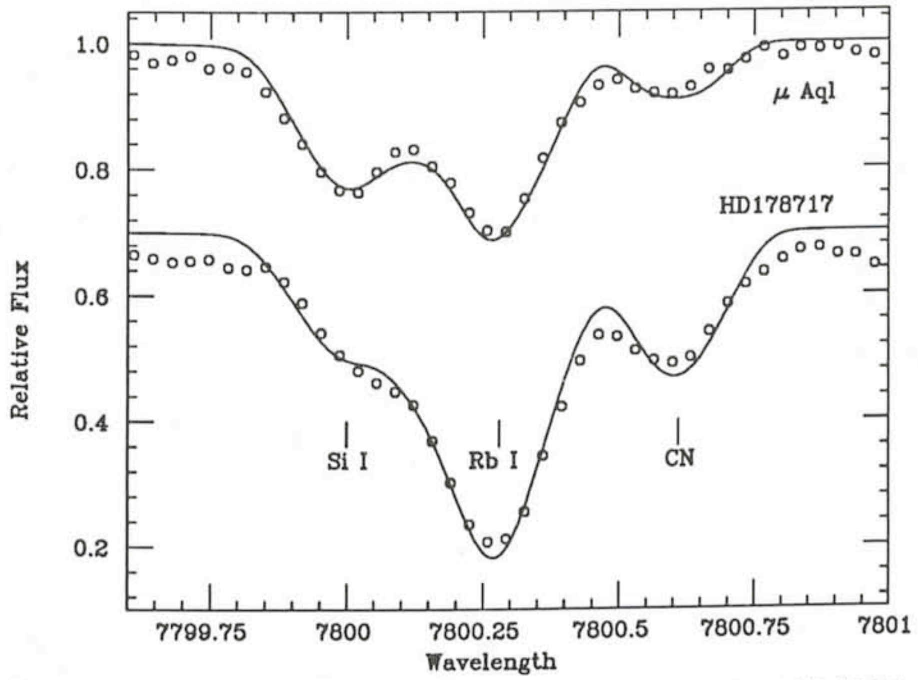

Figure 3: *The observed and best-fit synthesized spectra for μ Aql (top) and HD 178717 (bottom; a constant is subtracted from this spectrum) in the region of the Rb I 7800 Å line.*

Do these results imply that mass transfer from a low-mass AGB companion is the mechanism whereby the Ba II stars are formed? The $^{13}C(\alpha, n)^{16}O$ neutron source is believed to operate in such stars. It is normally assumed that the $^{13}C(\alpha, n)^{16}O$ neutron source does not lead to any significant alteration of the magnesium isotopes due to the small neutron absorption cross section of ^{16}O. However, recent calculations (Arnould and Jorissen 1986) have shown that it may be possible, in a limited parameter space, to produce observable anomalies in the magnesium isotopic mixture if it is assumed that all the CNO isotopes in the intershell region of the AGB star have been transformed into ^{22}Ne. In such circumstances, neutron absorption reactions on ^{22}Ne and up through the magnesium isotopes, could lead to a small observable excess of ^{25}Mg and ^{26}Mg similar to that observed in HD 178717. The question as to what fraction of the CNO isotopes are transformed into ^{22}Ne will be determined by the temperature history of the stellar interior, and the competition between the ^{22}Ne producing reaction sequence $^{14}N(\alpha, \gamma)^{18}F(\beta)^{18}O(\alpha, \gamma)^{22}Ne$, and destruction reactions such as $^{18}O(p, \alpha)^{15}N$. The fact that some Ba II stars show normal (i.e. solar) isotopic magnesium mixtures (Lambert 1985), whereas some do not, could simply be an indication of the different temperature histories of the different stars. Since the temperature structure of the star depends sensitively on the stellar mass, it is plausible that this is the stellar parameter determining any distortion of the magnesium isotopes.

Regardless of the stellar mass, the observed rubidium abundances of the Ba II stars either pose a serious problem for current AGB models, or else for the proposed mass transfer scenario. This can be seen from Figure 4 where a calculation (Malaney 1987) showing the Rb/Sr ratio as a function of neutron density is shown. The Rb/Sr ratio of HD 178717, which is also indicated, is deduced assuming a previously measured [Sr/Fe] ratio for the star. The horizontal dashed lines in Figure 4 correspond to the maximum and minimum value of the Rb/Sr ratio assuming a conservative error of $\pm$ 0.2 dex. Current models of the nucleosynthesis occurring in AGB stars, irrespective of the neutron source or core mass assumed, result in Rb/Sr ratios of at least 0.5. It can be seen from Figure 4 that the observed Rb/Sr ratio in HD 178717 indicates that the neutron density at the s-process site cannot be greater than $\sim 5 \times 10^7$ cm^{-3}. In contrast, the neutron densities of AGB stars are typically in the range of 10^9 – 10^{12} cm^{-3}. If we assume an AGB mass transfer mechanism as the correct interpretation of the Ba II star phenomenon, then the observed Rb/Sr ratio of HD 178717 would appear to be incompatible with current AGB models.

Conclusions

We find that a distribution of ^{26}Mg : ^{25}Mg : ^{26}Mg equal to 60 : 25 : 15 gives a good fit to MgH observations of the cool Ba II star HD 178717. This distribution would appear to rule out the operation of the $^{22}Ne(\alpha, n)^{25}Mg$ neutron source, and therefore any relationship of this Ba II star to intermediate-mass AGB stars. From our deduced rubidium abundance, we find for HD 178717 a neutron density of $\sim 2 \times 10^7$ cm^{-3} at the s-process site. If an AGB mass transfer mechanism is responsible for the s-process enhancements of Ba II stars, then,

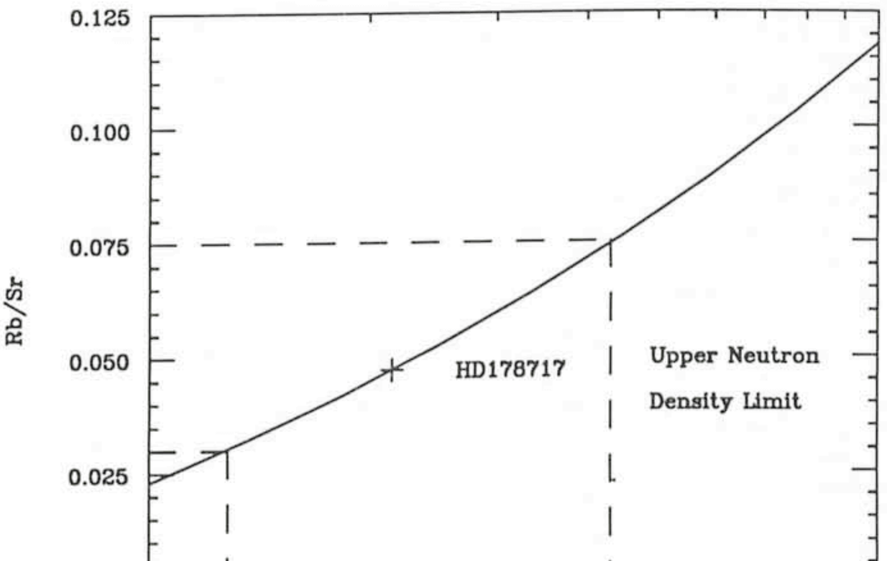

Figure 4: *The calculated Rb/Sr ratio as a function of the neutron density (solid curve). Also indicated (cross) is the measured value of Rb/Sr in HD 178717. The horizontal dashed lines correspond to our estimated error of this ratio. The vertical dashed lines are the resultant error limits on the neutron density.*

this low neutron density implies that significant revisions of present low-mass AGB models are required.

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References

Arnould, M. and Jorissen, A., 1986, in *Advances in Nuclear Astrophysics,* eds. E. Vangioni-Flam, J. Audouze, M. Chasse, J.P. Chieze and J. Tran Thanh Van, (Editions Frontières, France), p. 419.
Lambert, D.L., 1985, in *Cool Stars with Excesses of Heavy Elements,* eds. M. Jascheck and P.C. Keenan (Dordrecht: Reidel), p. 191.
Malaney, R.A., 1987, *Ap. J.,* **321,** 832.
Sneden, C., 1974, PhD Thesis, Univ. of Texas.

Of Whirls and Molten Gold

An Introduction to Fontenelle's "Entretiens" (1686)

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Whereas everybody agrees that there has been enormous progress in many areas of astronomy and astrophysics during recent years, nobody knows for sure which contemporary achievements of our science will be considered particularly important by scientists in a distant future. It is therefore sometimes interesting to place yourself in that privileged position by looking backwards in time and to judge the ideas of our forefathers in the light of our present knowledge.

Some time ago, when I glanced through A. Pannekoek's "History of Astronomy", I happened to come upon the name of Fontenelle. According to Pannekoek, whose text is one of the best introductions for non-specialists to the accomplishments of our predecessors, "Great popularity was won by Fontenelle's *Entretiens sur la pluralité des mondes* (Conversations on the Plurality of Worlds) 1686." I must admit that I had never heard of this author, but I became intrigued about the "plurality" and decided to find out what this was about. First I asked some of my colleagues about Fontenelle, but none of them seemed to know him. "At which observatory does he work?" was one of the kind, but not very helpful replies.

Calling the Bavarian State Library in Munich, I learned that no less than three editions of Fontenelle's book were available there, although it was slightly puzzling that the first was from 1687, the second from 1750 and the third from 1796! So I decided to have a closer look and soon entered a fascinating world, so different from our modern one, and yet in some regards so similar that it might also interest those readers of the *Messenger* who are not familiar with "Entretiens". Since I am not a specialist in the history of astronomy, the following account must of course only be taken as reflections of a modern astronomer when confronted with the thoughts of a popular writer in the late 17th century.

Popularization and Fontenelle

Any scientist, who has written articles that are destined to be read by a wider circle, knows that they have to be quite different from those that appear in professional journals. With the increasing importance of popularization of the sciences, in particular within the "natural" ones, more and more scientists go through this experience. Many of them do so because they feel that it is useful to call attention to the research at the institute where they work – in some countries the regular reporting in the media may even have a decisive influence on the funding. Some of their colleagues feel that they have a moral obligation to inform the taxpayers on whose money they subsist and others simply think it is great fun to tell about the work in which they are currently engaged.

The information flow from scientists to the media and onwards to the public is not a new phenomenon, although it may have become more intense in our days. We have all read the books by the fathers of modern science fiction, like Jules Verne and H.G. Wells, who based their thrilling stories on the science and technology of their epoch. Further back in time, the public interest in the natural sciences was often satisfied by dramatic accounts of journeys to distant continents. In astronomy, the so-called Broadsheets played an important role in conveying news about celestial phenomena, although they were not always to be trusted; see for instance the article by P. Véron and G. Tammann in the *Messenger,* **16,** 4, 1979.

Fontenelle's book, which was first published in 1686, is in retrospect a significant milestone in the noble art of science popularization and it contains elements from which even modern members of this trade may learn. The author was born in Rouen, France, on February 11, 1657 and he died in Paris on January 9, 1757, after a long and busy life. His full name was Bernard le Bovier, sieur de Fontenelle; his mother was a sister of the famous Pierre Corneille. He was educated by the Jesuits in Rouen. Having unsuccessfully tried his luck as a lawyer (he lost his first court case and left in disgust!), he then turned towards the sciences and later became one of the most read philosophers of his time. Voltaire described him as the most universal mind produced by the era of the "Sun King" Louis XIV.

Still in his twenties, he wrote libretti to two tragic operas and in 1683 he became well known by some philosophical treatises, followed by the "Entretiens", three years later. In 1697, he became permanent secretary of the French Academy of Sciences, a position that

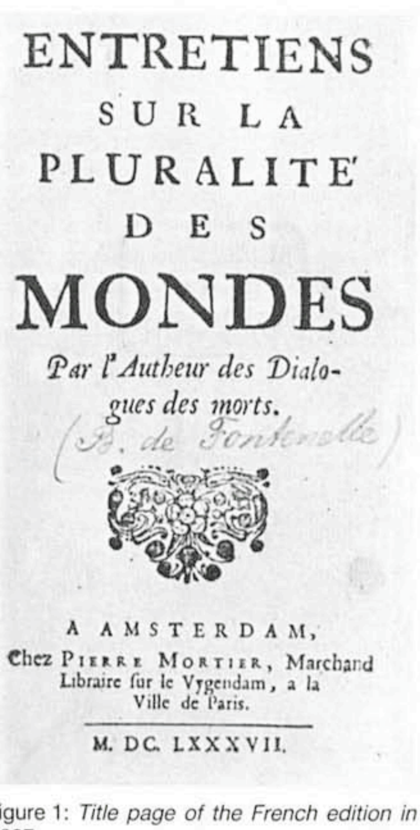
ENTRETIENS
SUR LA
PLURALITE'
DES
MONDES
Par l'Autheur des Dialogues des morts.
(B. de Fontenelle)
A AMSTERDAM,
Chez PIERRE MORTIER, Marchand
Libraire sur le Vygendam, à la
Ville de Paris.
M. DC. LXXXVII.

Figure 1: *Title page of the French edition in 1687.*