THE BARIUM STARS

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ABSTRACT: The Barium stars are reviewed in terms of their known binary nature and their quantitative abundance peculiarities. It is concluded that the most likely explanation of the ^{12}C and s-process overabundances observed in the Barium stars is mass transfer from a companion, which is now a white dwarf, but was once a ^4He-burning thermally-pulsing asymptotic giant branch star.

I. INTRODUCTION

The Barium stars certainly present a fascinating "recent" addition to the subject of "Interacting Binary Stars": it is only since 1980 that Barium stars have taken their rightful place as a particular type of binary system. The recognition of these stars as a class of binary stars is due largely to the work of Bob McClure and collaborators (the "discovery" paper being McClure, Fletcher, and Nemec 1980). We now can claim confidently that the Barium stars, which resisted for many years being placed in a convenient niche in the world of stellar evolution, can be understood as (formerly) interacting binary systems. In this talk we will review the history of the Barium stars, discuss the evidence which exposes their binary nature, and then use quantitative abundance analyses to link the abundance peculiarities observed in the Barium stars to those found in the asymptotic giant branch (AGB) stars which are undergoing ^4He-burning thermal pulses (TPs).

Recent reviews of the Barium stars can be found in Lambert (1985, 1988) and McClure (1989); these reviews emphasize different aspects of the topic, with Lambert discussing the chemical compositions while McClure provides detailed analyses of the orbital parameters. In this paper, we will discuss both the orbits and the abundance peculiarities of the Barium stars and argue that the simplest interpretation of the observations suggests strongly that these systems represent situations in which a former TP-AGB star transferred "chemically peculiar" matter onto a companion, which we now observe as the primary component in the binary system, while the former TP-AGB primary is now an optically invisible white dwarf.

2. HISTORY

The Barium stars were first recognized as a distinct class of objects by Bidelman and Keenan (1951); the stars considered to be members of the group were G and K giants which showed abnormally strong lines due to Ba II (λ4554 Å), Sr II (λ4077 Å), and an

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enhanced G-Band (due to CH) and the violet bands of CN. Both the Ba II and Sr II lines were known to increase in strength in supergiants (low pressures), however, the Barium stars did not appear to be supergiants and Bidelman and Keenan concluded that the peculiar line-strengths were probably due, in part, to an enhanced carbon abundance. In fact, they suggested that the Barium stars probably had similar abundances to the much cooler S stars and N-type carbon stars. The Barium stars also exhibited some spectral similarities to the CH stars, found by Keenan (1942), except that the CH stars tended to have stronger CH and CN bands, but weaker "metal" lines. Garstang (1952) identified many enhanced lines, due principally to Y, Zr, La, Ce, Pr, Nd, and Sm, from a high-dispersion spectrum of the Barium star ζ Cap. Lines due to iron-group elements, including ionized lines, were not strengthened in comparison to normal giants, confirming the suspicions of Bidelman and Keenan (1951) that the Barium stars had peculiar atmospheric abundances rather than low electron pressures and/or a low opacity.

The first quantitative abundance analysis of a Barium star was by Burbidge and Burbidge (1957) for HD 46407 (K0p): this was a differential curve-of-growth using κ Gem (G8III) as the standard star. They showed that most elements heavier than strontium were overabundant in HD 46407 and the pattern of heavy-element overabundances was consistent with the material having been exposed to the slow capture of neutrons as suggested by Burbidge, Burbidge, Fowler, and Hoyle (1956; B^2FH): this is the so-called s-process. Additional studies (Warner 1965; Tech 1971) confirmed the heavy-element overabundances of the Barium stars and the general agreement of these overabundances with predictions from s-process nucleosynthesis.

Abundance analyses which included the important trio of elements carbon, nitrogen, and oxygen were provided by Tomkin and Lambert (1979), Smith, Sneden, and Pilachowski (1980), Sneden, Lambert, and Pilachowski (1981), Smith (1984), and Kovacs (1985). These studies found that the Barium stars exhibited enhanced N-abundances and normal O-abundances ([N/Fe] ~ +0.3 and [O/Fe] ~ 0.0, where $[A/B] \equiv \log (N(A)/N(B))_{\text{Program Star}} - \log (N(A)/N(B))_{\text{Standard Star}}$ and where the "Standard Star" abundance ratios are typically solar), which are what are observed in the G and K giants. The enhanced N abundances and normal O in the G and K giants are the result of the "first dredge-up" of CN-processed material on the RGB and is accompanied by a decrease in the ^{12}C abundance (Lambert and Ries 1981). For carbon, however, the above studies found that, relative to the G and K giants, the Barium stars had carbon abundances which ranged from those found typically in the G and K giants up to three or more times these values. Compared to the G and K giants of similar T_{eff} and log g (or luminosity), the Barium stars thus usually show excesses of carbon (in the form of ^{12}C) and the heavy s-process elements. The production of ^{12}C, along with the s-process species, has been associated with the luminous TP-AGB phase of stellar evolution (Schwarzschild and Härm 1967; Sanders 1967; Iben 1975; Iben and Truran 1978); for a detailed reiew of this phase of evolution, see Iben and Renzini (1983).

The "problem" of the Barium (and CH) stars arose due to the association of those very elements observed to be overabundant in these objects (^{12}C and the s-process) with the very luminous (M_{bol} ~ -5 to -6) TP-AGB phase of stellar evolution; studies of the Barium and CH star luminosities (MacConnell, Frye, and Upgren 1972; Scalo 1976) found them to be characterized by much lower luminosities, typical of luminosity-class III red giants (M_{bol} ~ +1 to -3). In addition, McClure, Forrester, and Gibson (1974) found two Barium stars in the old open cluster NGC 2420, which has a known distance modulus: these two Barium red-giants were well below TP-AGB luminosities.

The discrepancy between the high luminosities of the TP-AGB stars and the lower luminosities attributed to certain types of stars which show the expected products of ^{4}He-burning thermal pulses in their atmospheres has been compounded by Bond's (1974) discovery of the CH subgiants. This class of stars is composed of F- and G-type dwarfs that show the same abundance peculiarities (^{12}C and s-process enrichment) found for the Barium and CH giants; their abundance similarities to the Barium and CH giants, as well as the high surface gravities expected for subgiant or main-sequence stars, have been confirmed by the abundance analyses of Sneden and Bond (1976), Luck and Bond (1982, 1991), Sneden (1983), and Krishnaswamy and Sneden (1985). More recently, Tomkin *et al.* (1989) and North and Duquennoy (1990) have found two F dwarfs enriched in s-process elements: the "Barium star phenomena" thus spans the luminosity range from dwarf to giant.

It is difficult, if not nearly impossible, to produce the ^{12}C and s-process elements via nuclear processes internal to such low-luminosity objects, such as the CH subgiants, F dwarfs, or first-ascent giants. A promising solution to this mystery was provided by McClure, Fletcher, and Nemec (1980), who pointed out that probably all Barium stars were single-line spectroscopic binaries. At about the same time, Böhm-Vitense (1980) discovered that one of the well-known Barium stars, ζ Cap, had a white-dwarf companion which was detected via UV spectroscopy with IUE. If Barium stars all had white-dwarf companions (which were, at an earlier time, TP-AGB stars), this would allow the nucleosynthesis to proceed as expected in the former TP-AGB star which, through mass loss, would then transfer mass enriched in ^{12}C and the s-process elements onto its companion, which we now observe as the Barium star. Further radial-velocity studies by McClure (1983, 1984b, 1989) and McClure and Woodsworth (1990) have demonstrated that probably all Barium and CH giants, as well as CH subgiants, are binaries with companions that have masses expected for white dwarfs. Numerous attempts to detect the spectra of these white dwarfs in the UV using IUE have had mixed results (Böhm-Vitense 1980; Dominy and Lambert 1983; Böhm-Vitense *et al.* 1984; Bond 1984), with only a few white-dwarfs detected directly. However, given the somewhat uncertain distances to the Barium and CH stars, coupled with IUE's limited sensitivity, it is not clear whether the large fraction of non-detections is a serious problem for the "mass transfer" hypothesis: more careful scrutiny with HST should help here.

We now discuss the spectroscopic orbits and quantitative abundances of the Barium stars to see if the mass transfer hypothesis really is a viable explanation for the "Barium star" problem.

3. THE ORBITS

Having discovered that the Barium and CH stars are all binaries (McClure, Fletcher, and Nemec 1980; McClure 1983), a long-term radial-velocity monitoring program by McClure and collaborators has resulted in the most recent spectroscopic orbital elements being summarized in McClure and Woodsworth (1990): included here are orbital elements for 16 Barium and 8 CH stars. In this section we summarize the results from this paper, which includes more orbits than an earlier paper (McClure 1983) whose results were discussed by Webbink (1986).

Figure 1 shows a frequency histogram of the orbital eccentricities for the Barium and CH stars from McClure and Woodsworth (1990), along with a sample of eccentricities from normal G and K giant spectroscopic-binary systems collected by them from the work of Griffin (1983, 1984a,b, 1985a,b,c, 1986a,b, 1988a,b): this sample of G and K giant binaries acts as a "control group" to compare to the Barium and CH binaries. The G and K giant binaries have been restricted to those having periods which overlap those found in the Barium and CH systems ($P \gtrsim 80$ days). The results displayed in Figure 1 show clearly that the Barium stars and (especially) the CH stars tend to have smaller orbital

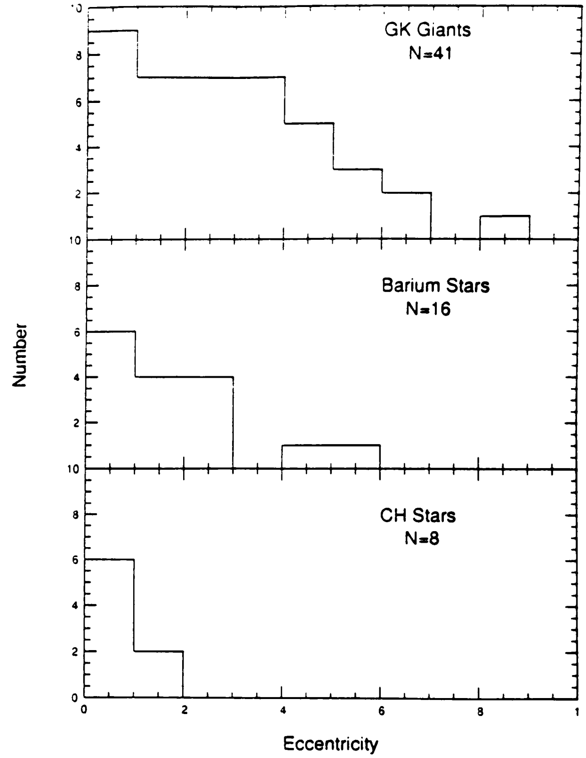

Figure 1: Frequency histograms of the eccentricities of the spectroscopic orbits of "normal" G and K giants along with the Barium and CH giants (McClure and Woodsworth 1990). Note the tendency for the Barium and (especially) CH binaires to have lower eccentricities than the G- and K-giant binaries.

eccentricities than the binary G and K giants. As shown by McClure and Woodsworth (1990), this lack of higher-eccentricity systems amongst the Barium and CH stars is statistically significant and is a clear suggestion that some sort of dissipation of the original orbital energy has taken place: mass transfer could be the source of such dissipation. Although the frequency distribution of the eccentricities of the Barium stars is skewed towards smaller values (relative to the normal giants), there is still a substantial fraction of non-zero eccentricities and, as pointed out by Webbink (1986) and discussed in McClure and Woodsworth (1990), this argues against the Barium stars having been semi-detached binaries due to the fact that mass transfer via Roche-Lobe overflow, or common envelope evolution, quickly damps orbital eccentricity. It is possible, as suggested by Webbink (1986), that the Barium star's companion nearly filled its Roche Lobe in the past and that this caused some amount of tidal dissipation, but no mass transfer via Roche-Lobe overflow. Boffin and Jorissen (1988) argue that the necessary mass-transfer in the Barium stars occurred through the accretion of the slow stellar wind from an AGB star onto the star which we now observe as the primary: more realistic modelling of this type of mass transfer is explored in this volume by Boffin (1992). The situation for the CH stars is somewhat different; McClure and Woodsworth (1990) point out that here the distribution of eccentricities "is not inconsistent with a sample of binaries with circularized orbits, which sugests that common-envelope evolution could have taken place". Whether this apparent difference in eccentricities between the Barium and CH stars means significantly different types of mass transfer has taken place remains to be seen: we note that the CH stars represent a lower-metallicity, higher-velocity population than the Barium stars and, thus, the CH binaries are probably older systems with current primary stars of lower mass.

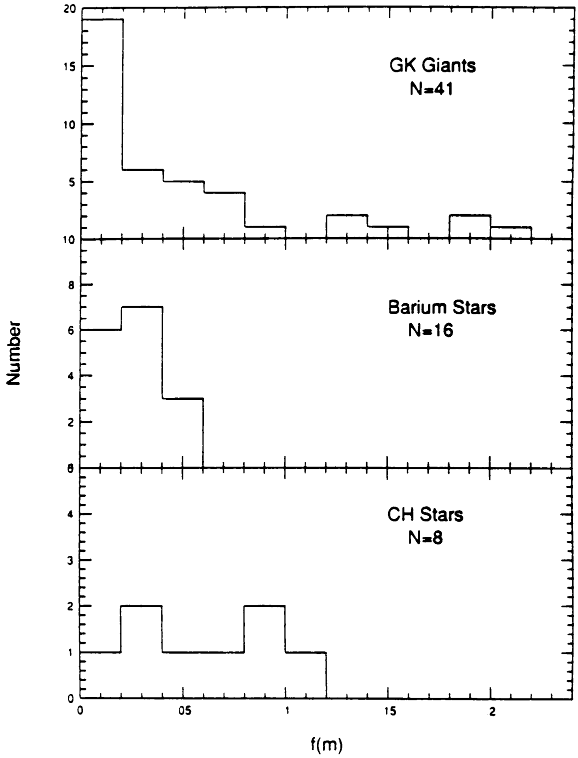

Figure 2: Frequency histograms of the derived mass functions, f(m), for the "normal" G- and K-giant binaries, plus the Barium and CH systems (McClure and Woodsworth 1990). The Barium and CH binaries lack the tail of larger mass functions (f(m) > 0.1 $M_{\odot}$) found in the G- and K-giant distribution. It is argued by McClure and Woodsworth that the observed distributions of f(m) for the Barium and CH binaries are consistent with their having secondary companions with masses typical of those expected for white dwarfs.

In Figure 2 we now present the frequency histograms of the mass functions, f(m), for the G and K giant binaries, the Barium stars, and the CH stars: the mass function is defined as

$$f(m) = \sin^3 i \, \frac{m_2^3}{(m_1 + m_2)^3},$$

where m_1 is the primary's mass, m_2 the secondary's mass, and i the orbital inclination on the sky. As with the eccentricities, the mass functions of the Barium and CH stars are distributed differently than the normal G- and K-giant spectroscopic binaries. Specifically, both the Barium and CH systems lack the "tail" in the distribution of the G and K binaries towards larger values of f(m). In addition, the distribution in f(m) for the Barium stars is weighted to the low mass-functions relative to the CH stars.

Because the expresion for f(m) contains the orbital inclination, i, which is not determined for single-line spectroscopic binaries, the individual mass ratios are not known for the Barium and CH binaries. However, comparisons between the observed distributions and a model distribution composed of "true" mass functions,

$$f'(m) = \frac{m_2^3}{(m_1 + m_2)^2},$$

which are distributed randomly in inclination, can usefully be made. When carrying out such an exercise, McClure and Woodsworth (1990) find that the observed distribution in f(m) for the Barium stars can be quite closely modelled with a narrowly peaked distribution in the true mass function of the form of a Gaussian with $f'_0(m) = 0.04\ M_\odot$ and a small dispersion of $s = 0.01\ M_\odot$. The situation for the CH stars is similar, except that the true mass function has $f'_0(m) = 0.095\ M_\odot$ with a dispersion of $0.015\ M_\odot$. These results are very different for the normal G- and K-giant spectroscopic binaries, which require a true mass function having a substantial tail towards larger values ($f'(m) \sim 0.1\text{-}0.3\ M_\odot$).

Given such a narrow range of true mass functions for the Barium and CH binaries, McClure and Woodsworth estimate typical secondary masses by assuming plausible primary masses. For the Barium stars, based upon kinematics of these stars as a group and the fact that the intermediate-age cluster NGC 2420 contains two Barium stars, they estimate primary masses of $m_1 \sim 1\text{-}3\ M_\odot$. Using these extreme values of the estimates for the primary masses along with a true mass function value of $0.04\ M_\odot$, one derives secondary masses of $m_2 \sim 0.45\text{-}0.85\ M_\odot$: these values for m_2 nicely span the masses of most white dwarfs. As the CH stars represent an older population (based upon their kinematics, metallicities, and the fact that some CH stars exist in globular clusters), McClure and Woodsworth assign an estimated primary mass of $m_1 = 0.8\ M_\odot$ for these systems. Now, using the derived peak in the mass function of $0.095\ M_\odot$, one derives a typical secondary mass of $m_2 \approx 0.56\ M_\odot$: again, this result for the secondary mass coincides well with the mass of a white dwarf.

4. THE ABUNDANCES

Several references to quantitative abundance analyses were mentioned in the Introduction, and our self-appointed task here is to test the mass-transfer hypothesis by using these abundances. Recall that the Barium and CH stars exhibit the abundance peculiarities expected from the TP-AGB phase of stellar evolution (^{12}C plus the s-process elements), but are typically found at the much lower luminosities of core He-burning giants, first-ascent giants, or subgiants. With the recent abundance results as our data, a direct comparison can be made between many of the red giants of different types: this was first used extensively in the review by Lambert (1985).

In Figure 3 we gather ^{12}C/^{16}O ratios and s-process abundances (in the form of [s/Fe] where 's' is the average of the Y, Zr, and Nd abundances) for the G and K giants

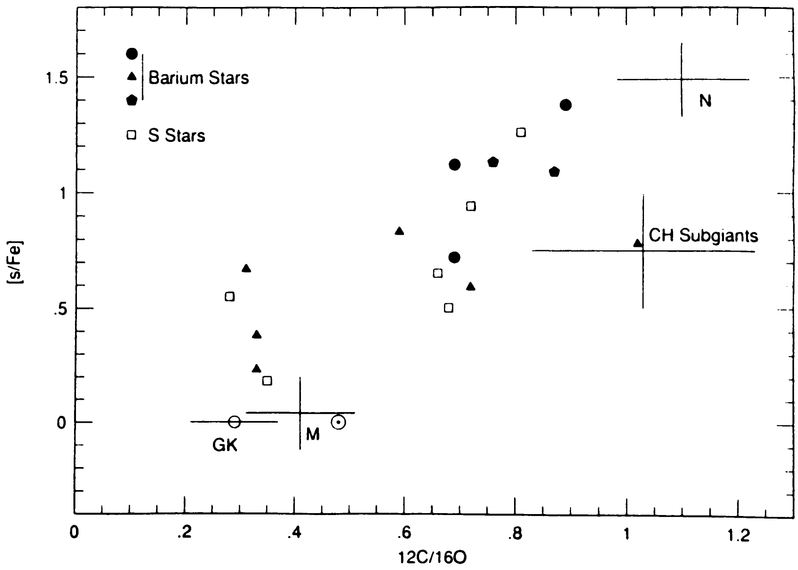

Figure 3: The s-process abundances (with [s/Fe] ≡ [(Y,Zr,Nd)/Fe]) as a function of $^{12}C/^{16}O$ for various samples of stars (the sources for these abundances can be found in the text). Note the trend of increasing [s/Fe] with the $^{12}C/^{16}O$ ratio from the GKM giants through the S stars to the N-type carbon stars; this correlation is expected from TP-AGB nucleosynthesis. The Barium stars fall right on this trend and thus have very similar abundances to the more luminous TP-AGB stars.

from Lambert and Ries (1981), for the M giants from Smith and Lambert (1990), and the N-type carbon stars with $^{12}C/^{16}O$ from Lambert *et al.* (1986) and [s/Fe] from Utsumi (1985; where we use Utsumi's Ti-abundance in place of Fe). The crosses represent the means and standard deviations of the samples; for the G and K giants from Lambert and Ries, we assume [s/Fe] = 0.0 as heavy-element abundances were not available for all of the stars. The open squares are S stars from Smith and Lambert (1990), where we only plot those S stars which contain the unstable s-process technetium: ^{99}Tc has a ground-state half-life of about 2 x 10^5 yr and should be visible during virtually all of the TP-AGB lifetime. Nearly 40% of all MS and S stars do not show any trace of the Tc I resonance lines (Little, Little-Marenin, and Bauer 1987; Smith and Lambert 1988) and these authors have argued that these "non-Tc" S stars are actually binary stars with white-dwarf companions, similar to the G- and K-giant Barium stars. These binary S-stars would presumably owe their ^{12}C and s-process overabundances to mass transfer from a former TP-AGB primary, just like the Barium stars; for a review of these binary S-stars see Johnson (1992 - this volume). In order to isolate a true TP-AGB sample of S stars, we plot only the Tc-containing S stars in Figure 3. It is clear from Figure 3 that the G, K, and M giants have slightly lower $^{12}C/^{16}O$ ratios, relative to solar (this is the result of the first dredge-up), with the M giants having nearly solar [s/Fe] abundances, while the N-type carbon stars have elevated $^{12}C/^{16}O$ and [s/Fe] abundances. In this type of diagram, the S stars are a clear transition group spanning the range between the "normal" GKM giants and the N stars, with increasing ^{12}C abundances (the abundance analyses show [^{16}O/H] to remain virtually unchanged) going with increasing s-process abundances. Plotting the

Barium star abundances (Sneden *et al.* 1981; Smith 1984; Kovacs 1985) we see that the trend from the GKM giants towards the N stars followed by the S stars is also followed by the Barium stars. The relationship between ^{12}C and the s-process arises in the environment of the ^{4}He-burning thermal pulses on the AGB and it is unlikely that the physical conditions and timescales which define the nucleosynthesis which occurs during this phase of stellar evolution will be duplicated in the lower-luminosity subgiants, first-ascent giants, or core ^{4}He-burning stars. The Barium stars exhibit exactly the same proportions of s-process heavy elements to ^{12}C that the true TP-AGB stars possess and, as the Barium stars are known binaries with probable white-dwarf companions, the simplest explanation is that the atmospheres of the Barium stars have been polluted by varying fractions of material from N or S stars.

We also show in Figure 3 the mean and standard deviation of ^{12}C/^{16}O and [s/Fe] for a sample of 9 CH subgiants from Smith, Coleman, and Lambert (1992). As mentioned in the Introduction, the CH subgiants were identified by Bond (1974) and have been shown to be low-luminosity stars at, or near, the main sequence. Relative to the Barium stars, the CH subgiants analyzed by Smith *et al.* (1992) have a larger ^{12}C/^{16}O ratio at a given value of [s/Fe]: qualitatively, this is to be expected if the mass transfer has occured onto stars near the main sequence, due to the fact that the deep convective envelope of a G, K, or M giant contains substantial quantities of matter depleted in ^{12}C through the CN cycle. As this sample of CH subgiants evolves to higher luminosities with their convective envelopes growing in mass, the surface ^{12}C and s-process abundances will be lowered by the addition of interior material with smaller abundances of ^{12}C and the s-process elements. Mixing the current convective envelope of these stars with an equal amount of material typical of the GKM giants would move the CH subgiant distribution towards the lower left in Figure 3 onto the region of the diagram occupied by some of the Barium stars: these stars would now resemble the CH giants. This potential connection between the CH subgiants and the higher-luminosity CH and Barium giants has been discussed at length by Luck and Bond (1991).

Another interesting comparison that can be done between the Barium stars and other samples of giants involves the ^{12}C/^{13}C ratio: in Figure 4 we plot ^{12}C/^{16}O versus the ^{12}C/^{13}C ratio. Adding pure ^{12}C (from ^{4}He-burning) to a G, K, or M giant, with an already low ^{12}C/^{13}C ratio, would move a star along a straight line towards larger ^{12}C/^{16}O and ^{12}C/^{13}C ratios in Figure 4. The GKM giants occupy the lower-left region of this diagram with ^{12}C/^{16}O ~ 0.2-0.4 and ^{12}C/^{13}C ~ 5-20: the solid lines show the paths due to the addition of pure ^{12}C to stars with initial ratios of 0.25 and 5 or 0.25 and 20 in ^{12}C/^{16}O and ^{12}C/^{13}C, respectively. All of the N stars and most of the S and SC stars (from Dominy, Wallerstein, and Suntzeff 1986) fall within this envelope and thus can be represented by the addition of ^{12}C into the envelope of a G, K, or M giant. The vertical dashed line represents the CN-cycle equilibrium value of ^{12}C/^{13}C = 3.5; one SC star, WZ Cas, and one S star, TV Aur, have larger ^{12}C/^{16}O ratios and lie near the CN-equilibrium line and cannot be represented by the simple addition of ^{12}C to the surface abundance of a GKM giant. Most of the Barium stars in Figure 4 fall within the bounds of the GKM-S-SC-N sequence of ^{12}C/^{13}C and ^{12}C/^{16}O; again, the Barium stars follow closely the sequence traversed by the GKM giants through the S and SC stars and towards the N-type carbon stars along the TP-AGB. Two of the Barium stars in Figure 4, HD's 121447 and 178717, lie tantalizingly close to the positions occupied by WZ Cas and TV Aur, with ^{12}C/^{16}O ~ 0.7 and ^{12}C/^{13}C ~ 8 for these two cool Barium stars. As discussed, for example, in Smith and Lambert (1990), this position in the ^{12}C/^{16}O-^{12}C/^{13}C diagram could arise if some ^{12}C, from a ^{4}He-burning thermal pulse, is converted to ^{13}C at the base of a deep, "hot-bottom", convective envelope during an interpulse period. Although the few Barium stars for which ^{12}C/^{13}C ratios are available resemble the S, SC, and N stars, it would be desirable to determine carbon isotope ratios in a much larger sample of Barium stars.

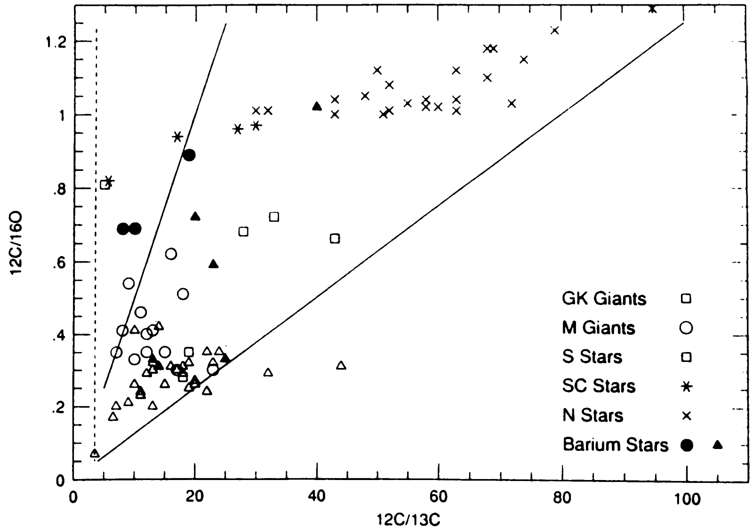

Figure 4: ^{12}C/^{16}O ratios versus ^{12}C/^{13}C for various samples of red giants: the sources for these abundances are found in the text. The solid lines represent the addition of pure ^{12}C to ^{12}C/^{16}O and ^{12}C/^{13}C ratios which are found at extremities of the GKM-giant distribution. Most of the S, SC, and N stars (TP-AGB stars) fall within the envelope defined by these two solid lines: these stars can "evolve" in the ^{12}C/^{16}O-^{12}C/^{13}C plane by the simple addition of ^{12}C to the GKM-giant distribution. Most of the Barium stars also occupy this envelope with the S, SC, and N stars. The vertical dashed line represents the equilibrium CN-cycle ^{12}C/^{13}C ratio of 3.5.

The final element we discuss is fluorine; the recent work by Jorissen, Smith, and Lambert (1992) has shown that ^{19}F is overabundant in the S, SC, and carbon stars, with [^{19}F/^{16}O] correlating strongly with ^{12}C/^{16}O. Jorissen *et al.* (1992) argue that ^{19}F synthesis is tied to the ^{4}He-burning thermal pulses with the chain $^{14}\mathrm{N}(\alpha,\gamma)^{18}\mathrm{F}(\beta^{+},\nu)^{18}\mathrm{O}(p,\alpha)^{15}\mathrm{N}(\alpha,\gamma)^{19}\mathrm{F}$ being responsible for fluorine production (the protons come from $^{13}\mathrm{C}(\alpha,n)^{16}\mathrm{O}$ followed by $^{14}\mathrm{N}(n,p)^{14}\mathrm{C}$). In two of the coolest Barium stars where the infrared HF lines are detectable (HD's 121447 and 178717), Jorissen *et al.* (1992) find ^{19}F overabundances that are comparable to the S, SC, or carbon stars: these fluorine enhancements are powerful pieces of evidence that the material in these Barium stars has been exposed to thermal-pulse ^{4}He-burning.

It is clear from the various quantitative abundances (^{12}C/^{16}O, [s/Fe], ^{12}C/^{13}C, [^{19}F/^{16}O]), which are demonstrably altered by TP-AGB evolution in the S, SC, and N stars, that the Barium G and K giants show indistinguishable abundance signatures from these cooler and more luminous red giants. As the Barium stars have almost certainly never been TP-AGB stars, but have companions which almost certainly have, the close abundance connection to true TP-AGB stars leads us to the simplest explanation of mass transfer as the source of the abundance peculiarities observed in the giant Barium and CH stars, the CH subgiants, the F dwarfs with enhanced s-process abundances (Tomkin *et al.* 1989), as well as the S stars without Tc.

5. SUMMARY

We have come down directly in support of the mass-transfer hypothesis as being the probable explanation for the main abundance peculiarities observed in the Barium and CH giants, the CH subgiants, the s-process enriched F dwarfs, as well as the S stars without technetium: we choose this hypothesis largely because it is the simplest explanation to explain most of the observations. McClure and collaborators have shown that these peculiar giants really are binaries, with companions whose probable masses span the mass range expected for white dwarfs. The spectroscopists have quantitatively linked the abundance peculiarities observed in the Barium and CH stars with true TP-AGB stars. These observations certainly do not prove the hypothesis - both observers and theorists need to continue to attack the Barium stars, as well as their stellar cousins, to either add strength to the hypothesis, or weaken it: the final word on the Barium stars is far from being written.

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