news and views

Not so wealthy stars?

from M. G. Edmunds

PERHAPS the most controversial issue of recent years in the determination of the chemical composition of stars has been the interpretation of the spectra of the so-called "Super-Metal-Rich" (SMR) stars. An interesting analysis of three K giant stars by Ruth Peterson (*Astrophys. J. Suppl.*, **30**, 61; 1976) may help to resolve the disagreement.

The problem may be outlined as follows. The strength of an atomic absorption line in the spectrum of a star is a function of the physical conditions and atomic abundances in the star's atmosphere. Analysis consists of assuming a model of the atmosphere and adjusting the atomic abundances until theoretical line strengths match the observed strengths. It has usually been assumed in abundance analysis that the structure of the atmosphere of a K giant star is uniquely determined by specifying a temperature (on the basis of the distribution of continuum radiation from the star), an acceleration due to gravity and an overall metal abundance—metals meaning all elements heavier than helium. The atmospheric elemental abundances in a K star reflect the composition of the interstellar medium out of which it formed. Most stars have a metal abundance similar to that of the Sun, yet there exist certain stars with absorption lines unusually strong for their assumed atmospheric physical conditions, implying that they have a considerably greater abundance of metals ("SMR") than the majority of stars. Comparison of the luminosities and temperatures of SMR stars with theoretical calculations of stellar evolution has suggested that some of them are considerably older than many stars of lower, solar metal abundance. Thus the SMR stars would not be consistent with the fairly well established near constancy, or slow increase, of the metal abundance of the interstellar medium out of which the stars are born, after a rapid increase in metal abundance during the formation of the Galaxy. So dispute has arisen over whether the anomalous strength of absorption lines in SM stars really does represent an over-abundance of metals.

What Peterson has done is to pro-

vide evidence that the line strengths of the SMR stars are consistent with a normal abundance of most metals, but an unusual atmospheric structure. She selected three stars of very similar temperature and surface gravity to minimise the difference of atmospheric physical conditions between the stars. One of them is the SMR giant μ Leo and another the normal giant κ Oph. By obtaining high quality image-tube observations of the spectra she was able to compare the strengths of fairly weak (and consequently difficult to observe) lines between the stars. The use of weak lines is advantageous since it very much reduces the influence on the line strength of uncertain non-thermal velocity fields and atomic collisions. In a K star atmosphere the conditions are such that atoms are either neutral or once ionised. Peterson shows that lines which are from the predominant species in the ionisation equilibrium (a function of ionisation potential of the element) imply that the metal abundance differences between the stars are at most a few percent. Lines arising from the minor species in the ionisation equilibrium are very sensitive to temperature, and it is these lines which differ in strength between the SMR μ Leo and the normal κ Oph. Peterson shows that the difference can be simply accounted for by a lower temperature in the outer layers of μ Leo's atmosphere. She also shows that normal abundances and the alteration of atmospheric structure is consistent with the anomalously strong absorption observed in photometric spectral bands which first suggested the existence of SMR stars.

But why do SMR stars have atmospheric structures different from normal stars? The one element that really does seem to be over-abundant in μ Leo is nitrogen, by a factor of about two.

Peterson speculates that the high nitrogen abundance results in an increased CN molecular abundance in the atmosphere. This molecule could contribute a large number of absorption lines in the near infrared, and by the requirement of energy conservation in the radiation field this will result in a lowering of the temperature in the

atmospheric region where the absorption occurs. It remains to be seen if theoretical stellar atmosphere models computed with variable molecular absorption can give quantitatively the required drop in temperature.

There also remains the problem of why the nitrogen abundance is high in the atmospheres of SMR stars. But the excess of this one particular element may prove easier to explain than the previous problem of over-abundance of metals thought to be formed in the extreme conditions of supernova explosion. Nitrogen may be formed in nuclear reactions occurring in the core of moderately massive giants, and it could subsequently be mixed up to the surface. Yet this would imply the reaching of a particular evolutionary stage before a star became SMR. Much work remains to be done to see if all suspect SMR stars are consistent with normal metal abundances except for a nitrogen over-abundance, and to check that such over-abundance can be accounted for by the normal evolution of the stars.

A hundred years ago

WE will leave to other journals the task of criticising the present Exhibition of works of Art at the Royal Academy, and without entering deeply into the question of grouping composition, solidity of painting, *chiaroscuro*, perspective, *morbidezza* of flesh treatment, or aerial effect, we will confine ourselves to a few remarks in a less ambitious key, on those pictures which portray animal life. Of this class there are several important examples devoted entirely to the representation of wild or domesticated animals, with others in which the lower forms of creation play but a slightly inferior part; and in these days when the public taste claims a far more conscientious treatment of the subject than in former times, we may be allowed, without being taxed with unfair criticism to examine how far the respective artists have succeeded in fidelity of execution. from *Nature*, **14**, June 1, 105; 1876.