WOLF RAYET STARS AND THE ORIGIN OF THE ^{22}Ne EXCESS IN COSMIC RAYS

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First order Fermi acceleration at the boundary between supersonic stellar winds from OB and Wolf-Rayet stars and the surrounding interstellar medium could be influential in the bulk energization of the local cosmic radiation (Cassé and Paul, 1980). Since wind acceleration is not supposed to accelerate thermal particles, a continuous injection of low energy particles ($E \sim 1$ to 10 MeV/n) is required. We keep open the possibility that these particles may be injected from the interior of the stellar cavity, i.e. by the mass-losing star itself via a flare-like surface activity for instance. Observations of flare activity on hot and massive stars are mandatory to settle this idea. In this context, we expect that the CR reservoir is the surface of young and active stars and that the difference between the CR source (CRS) composition (i.e. corrected for propagation effects in the interstellar medium, ISM) and the surface composition of young stars (reflecting for most of them the present local ISM) is principally due to selective effects at injection depending on the atomic properties of the elements. This idea is supported by 3 arguments (Cassé and Goret, 1978, Meyer et al., 1979) i) the general resemblance between solar CR elemental abundances and elemental CRS abundances (see e.g. Mewalt, 1980) ii) the correlation between the (CRS/local galactic) abundance ratio and the first ionization potential and iii) the fact that dust grains must have been thoroughly destroyed in the medium from which CR are extracted. In the interstellar gas in which dust grains are present, Ni, Fe, Mg and especially Ca and Al are highly depleted (Salpeter, 1977) whereas they are normally abundant in CR.

The selective acceleration effects including a more subtle mass effect (Meyer et al., 1979) do not significantly alter the isotopic proportions of any given heavy element at the CR source. The isotopic composition is, therefore, the most genuine print of the thermonuclear origin of CR. At the present time, with our limited observations it seems that the isotopic CR composition inferred at the CR source is not strongly abnormal for the principal elements between H and Ni (see e.g. Balasubrahmanyan, 1979) except for Ne and possibly Mg. The ^{22}Ne/^{20}Ne ratio estimated at the CR source is thought to be about 3 times larger than the solar system isotopic ratio (see e.g. Balasubrahmanyan, 1979, and references therein). We are inclined to relate this pecularity to the fact that Wolf-Rayet stars of the WC type, whose surface abundances are expected to be enriched in helium burning products - and especially ^{22}Ne - could contribute significantly to the CR injection and acceleration (Cassé et al., in preparation).

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The role of WR stars in the CR energization has been illustrated in Cassé et al., (this conference). ^{22}Ne is believed to be the product of ^{14}N-burning through the sequence $^{14}N(\alpha,\gamma)^{18}F(e^{+}\nu)^{18}O(\alpha,\gamma)^{22}Ne$. This chain of reactions starts before the 3 α reaction (He-burning) and ends in the core of massive stars at the end of He-burning by $^{22}Ne(\alpha,n)^{25}Mg$. Since, according to stellar models, the helium core is never in contact with the external convective envelope in normal (H-rich) stars, or even pure Helium stars (see e.g. Stothers and Chin, 1977), the only way to get ^{22}Ne at the stellar surface is to remove the envelope and expose the convective core. It seems to be the case for massive helium stars (WC stars) resulting from Roche lobe overflow in close binary systems followed by stellar wind mass-loss (Vanbeveren and Packet, 1979). Assuming that every atom of CNO initially present in the volume occupied by the Helium convective core has been converted into ^{14}N and subsequently into ^{22}Ne, the ^{22}Ne excess would be at the surface of a typical WC star of the order of 130 (relative to solar system)*. Since the ^{22}Ne excess inferred at the CR source is about 3, the contribution of WC stars has to be at maximum 3/130, neglecting other possible sources of CR ^{22}Ne as e.g. explosive hydrogen burning (Cassé et al., 1979, Audouze et al., 1980). The dilution, in the proportion $\sim 1/40$, of the ^{22}Ne-rich component with the bulk of CR expected to be of normal composition would lower the He and C (and/or O) excesses of the extra-component to a level compatible with CRS abundances. Lower mass Helium rich stars like nuclei of planetary nebulaeare presently under study. A more quantitative estimate based on the work of Couch and Arnett (1972) lead essentially to the same conclusion (Cassé et al., in preparation). Finally the slight excess of ^{25}Mg and ^{26}Mg at the CR source found by Mewalt et al. (1979) would find an explanation in the framework of this model.

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* The Ne elemental excess will not appear in the spectra of WC stars because Ne lines are not observable in the visible and UV ranges.

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