HST FOS Spectroscopy of M2-29 and DDDM-1

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The halo planetary nebulae are of special interest insofar as the sample is very limited and they show a wide range of nebular chemical properties. We are interested in deriving their detailed nebular properties and to try to determine the characteristics of their progenitor stars. We selected M2-29 and DDDM-1 since they are the most deficient in Ar and S of their group. During HST Cycle 3 we obtained WFC1 direct imagery in Hα of them to derive information on their morphology and surface brightness for performing FOS spectroscopy.

M2-29

The imaging of this object revealed a complex structure, consisting of an inner ring, a jet, a knot at the end of the jet, a central oval shaped dense region, and a central condensation (stellar, with strong Hα emission).

From ground based spectrophotometry it was found that M2-29 has a high I(4363)/I-(5507) ratio, from which a high electron temperature and a low heavy element abundance was derived –T_e(O III) = 24000 K, and an O deficiency by a factor of 40 while the proportion of Ne/S/Ar/O is solar (Peña et al. 1991). It would be the PN with lowest derived O and Ne.

From HST FOS spectroscopy of the knot in M2-29 we derive T_e(O III) = 9310 K; from it we obtain an upper limit to C of < 13, and values of N/O/Ne/S of 76/310/110/3.3 per 10^6 H. This implies an O deficiency =of a factor of 3 relative to solar.

The difference between the 4363/5007 ratios observed with HST and from the ground cannot be attributed to observational errors and probably implies that there is a high density component, $N_e \geq 10^6 \text{cm}^{-3}$, close to the star that collisionally de-excites I(5007+4959). This component affects the ground based data (that incluedes most of the nebula) but not the HST data. Consequently the abundances derived from the ground based data are spurious while those derived from the knot are representative of the M2-29 abundances.

The low (C+N)/O ratio indicates that no 3-α products are present in the envelope and that probably only the first dredge-up took place in the star. Moreover under the assumption that N($initial$)/O = 0.03 it follows that C($initial$)/O is 0.22-0.26; this value is similar to that of DDDM-1 and probably implies that M2-29 is an old PN that was formed in the bulge before the C enrichment due to intermediate mass stars took place. The C/N upper limit implies that more than 84% of the C($initial$) was transformed into N due to the first dredge up.

DDDM-1

The derived values for C/N/O/Ne/Si/S/Ar/Fe are 14/25/15/21/3.8/3.4/0.73/2.2 per 10^6 H (in agreement with Clegg et al. 1987). That is, O, Ne, Ar and S are about a factor of six smaller than solar and imply that O, Ne, Ar and S were formed by type II SNe and that O was not produced by nuclear reactions in DDDM-1. Moreover the underabundance of the heavy elements imply that DDDM-1 is indeed a halo object.

The observed CN values have been affected by the CN cycle and could have been affected by 3-α reactions. The low C abundance probably implies that no dredge-up of 3-α

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products have taken place. The N/O ratio is higher than solar and than the values in O-poor galaxies implying that the CN cycle products have been dredged-up. By assuming that N(*initial*)/O = 0.03, (a typical value for O-poor galaxies), and assuming that the rest of the N was transformed from C, it follows that C(*initial*)/O = 0.23. This ratio is similar to that of irregular galaxies with similar O/H ratios like the SMC and considerably smaller than in the Sun and in the solar neighborhood H II regions. This result should be compared with stellar evolution models of metal-poor low mass stars.

The Fe/O ratio is similar to that of halo stars with similar O/H ratios and it is a factor of three smaller than the solar value. The low Fe/O ratio in DDDM-1 is due to the lack of contribution by Type Ia SNe to the Fe abundance of halo objects. Moreover it also implies that a negligible amount of Fe is trapped in dust grains.

The ratio Si/O = 0.025 can be compared to the solar value (0.043) and galactic B stars and supergiants (0.025-0.063). Since the fraction of Fe trapped in dust grains is negligible it is likely that the fraction of Si atoms trapped in dust is also negligible and the Si/O ratio might be representative of the abundances in the halo at the time DDDM-1 was formed. Interestingly enough the H II regions of O-poor irregular galaxies also show Si/O = 0.025, probably implying that the fraction of Si atoms tied up in dust grains inside the H II regions of these galaxies is also negligible.

These abundances can be used to constrain the initial stages of the chemical evolution of the Galaxy.

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