METAL-ENHANCED GALACTIC WINDS

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ABSTRACT: Constraints on supernova-driven galactic winds from elliptical galaxies at the epoch of star formation are investigated. The occurrence of mass loss is found to depend critically on the supernova rate in the case of dwarf galaxies, while the depth of the potential well is the most important constraint for giant ellipticals. The smallest dwarf ellipticals must have evolved from significantly more massive progenitors in order to have sustained a wind that carried away most of their metal production.

Galactic winds during the star formation epoch of elliptical galaxies offer an attractive explanation for the observed mass-metallicity relation, and in particular for the low metallicities and stellar densities of dwarf ellipticals (dE). These winds, enriched by the metals of all supernovae (SN) that power it, are metal-enhanced with respect to the star-forming gas (Vader 1986). Necessary conditions for the occurrence of a wind and the associated characteristic wind temperatures T are: (i) the hot dilute gas generated by SN explosions occupies most of space (T_p); (ii) a significant fraction of supernova remnants (SNR) overlap (T_w) or are pressure-confined before cooling radiatively (T_c); (iii) the wind energy exceeds the binding energy (T_e); (iv) the flow time of the wind is shorter than the radiative cooling time (T'_c). In terms of T we have

$$\max(T_e, T_c, T'_c,) < T < \min(T_p, T_w) \qquad \text{wind,}$$

$$\max(T_c, T_w) < T < T_p \qquad \text{'puffs'.}$$

A system with steady-state mass loss contains either fewer than 5 overlapping SNR's, each of which escapes directly (puffs), or many non-overlapping pressure confined SNR's (wind). For a given metallicity Z_g of the star-forming gas, each temperature T_x depends at most on the average rate per unit volume η of supernovae that power the wind and the velocity dispersion σ and radius r_e of the galaxy. Any equation $T_x = T_y$ thus defines a characteristic SN rate $\eta_c(\sigma, r_e)$. Star

T. de Zeeuw (ed.), Structure and Dynamics of Elliptical Galaxies, 435–436.

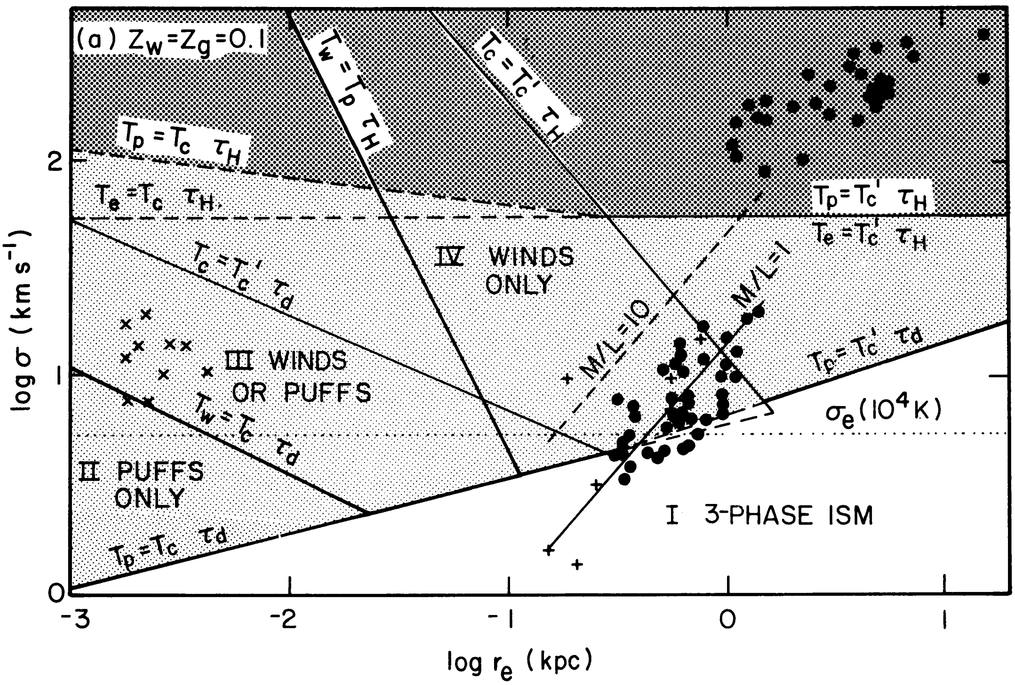

Fig. 1: Mass loss regions in the log σ – log r_e plane for a metallicity of the star-forming gas $Z_g = 0.1 Z_\odot$. Symbols denote: ● gE's; • and + dE's; x globular clusters.

formation time scales limited by the dynamical time scale τ_d of the system and the Hubble time $\tau_H = 10^{10}$ yrs yield the limiting values $\eta_L(\sigma, r_e)$, with L = d, H. Equating η_c to η_L yields relations of the form $\sigma = \sigma_L(r_e)$, which are displayed in Fig. 1 as lines labeled $T_x = T_y \tau_L$. Each of these lines marks the transition between different régimes of mass loss. In Fig. 1 we distinguish regions I (mass loss excluded), II (puffs only), III (winds or puffs), and IV (winds only). In the shaded areas mass loss can, but does not necessarily, occur. Giant ellipticals (gE) fall in the heavy-shaded area where a wind occurs independently of η if $T > T_e$. Globular clusters and dE's fall in the light-shaded area where mass loss can only occur given a sufficiently large SN rate. The smallest dE's fall in region I so that, if their low metallicities are due to mass loss, they must indeed have evolved from more massive progenitors.

A full account of this work will be published elsewhere (Vader 1987).

REFERENCES

Vader, J. P. 1986, Ap.J. 305, 669.
Vader, J. P. 1987, Ap.J.