A POWERFUL METHOD FOR DERIVING MASS-LOSS RATES FROM PLANETARY NEBULAE AND OTHER OBJECTS: THE FIRST ORDER MOMENT W_1 OF UNSATURATED P CYGNI LINE PROFILES

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For the case of optically thin lines, we show that the relation existing between the first order moment

$$W_1 \propto (E(\lambda)/E_c-1)\ (\lambda-\lambda_{12})d\lambda$$

of a P Cygni line profile and the quantity $\dot{M}$ n (level) (cf. Castor, Lutz and Seaton, 1981), where $\dot{M}$ is the mass-loss rate of the central star and n (level) the fractional abundance of the relevant ion, is in fact independent of any Sobolev-type approximations used for the transfer of line radiation. Consequently, all results established in the context of "very rapidly" expanding atmospheres (see Surdej, 1982) and mainly referring to the non-dependence of W_1 on various physical (underlying photospheric absorption line, limb darkening, collisions, multiplet line transitions, etc.) and geometrical (radial and rotational velocity fields, size of the atmosphere, etc.) effects remain unchanged for arbitrary (e.g. non-Sobolev type) outward-accelerating velocity laws.

Whenever applied with caution, the following relation

$$\dot{M}(-M_\odot/\text{year-})\ n\ (\text{level}) = -1.19\ 10^{-21}\ v^2_{max}(-\text{km/sec-})R^*(-R_\odot-)W_1/$$
$$(f_{12}\lambda_{12}(-10^3\text{Å}-)\ A(\text{element})),$$

where the different symbols have their usual meaning, thus provides a very powerful means of deriving mass-loss rates - with a total uncertainty less than 60 per cent - from the measurement W_1 of unsaturated P Cygni profiles observed in the spectrum of planetary nebulae, early as well as late-type stars, quasars, etc.

Castor, J.I., Lutz, J.H. and Seaton, M.J.: 1981, Monthly Notices Roy. Astron. Soc. 194, 547.
Surdej, J.: 1982, Astrophys. Space Sci. 88, 31.

PERINOTTO: Did you try to apply your method to any observed objects?
SURDEJ: Only to NGC 6543, for which we derive the same mass loss rate (to within 50%) as Castor, Lutz and Seaton.