A METHOD FOR CALCULATION OF LINE PROFILES IN EXPANDING ATMOSPHERES: APPLICATION TO WINDS FROM CENTRAL STARS OF PLANETARY NEBULAE

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1. INTRODUCTION

The structure of a stellar wind and its associated mass loss can be derived from the analysis of P Cygni-like line profiles. These do better occur in the UV range and have been extensively observed with the Copernicus (900 - 1450 A) and IUE Satellites(1150 - 3200 A).

Two main theoretical approaches have been developed so far to interpret these lines:

1) The Sobolev approximation with no turbulence, used e.g. in the Castor and Lamers (1979) atlas of theoretical profiles.
2) The comoving-frame method (Mihalas et al., 1975; Hamann, 1980).

The first method is not always able to reproduce the observed P Cygni profiles in early type stars. That is in the theoretical profiles:

a) The violet edge of strong lines is often too steep in comparison with the observed profile.
b) For strong lines the theoretical profiles are not able to reproduce the whole saturation of the absorption component.
c) The strength of the emission component is often overestimated.

The presence of turbulence in the wind has been shown to improve the fitting of theoretical profiles with observations (Hamann, 1980, 1981).

The second method is quite more accurate, but requires substantial CPU time on large computers.

A method more accurate than 1) and more practical than 2) would be then worthly.

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2. THE "SEI"METHOD

We have developed a method which uses the Sobolev approximation and solves exactly the equation of radiative transfer. ("SEI" = Sobolev with Exact Integration).

In particular:

a) it calculates line transfer even for doublets;
b) it takes into account the presence of underlying photospheric absorption lines;
c) it is accurate up to large optical depths;
d) it takes into account the presence of turbulence in the wind;
e) it allows to represent a wind having a wide range of physical conditions in temperature and in density;
f) it is fast enough to be of practical use with a medium size computer.

The profiles computed with the SEI method agree fairly well with the profiles computed with the comoving-frame method.

As an application, IUE high resolution profiles of the central star of the planetary nebula NGC 6826 have been fitted with theoretical profiles computed with the SEI method. The figures show the fits for an optically thick line (λ 1548.2, 1550.8 CIV) and for an optically thin line (λ 1718.6 NIV).

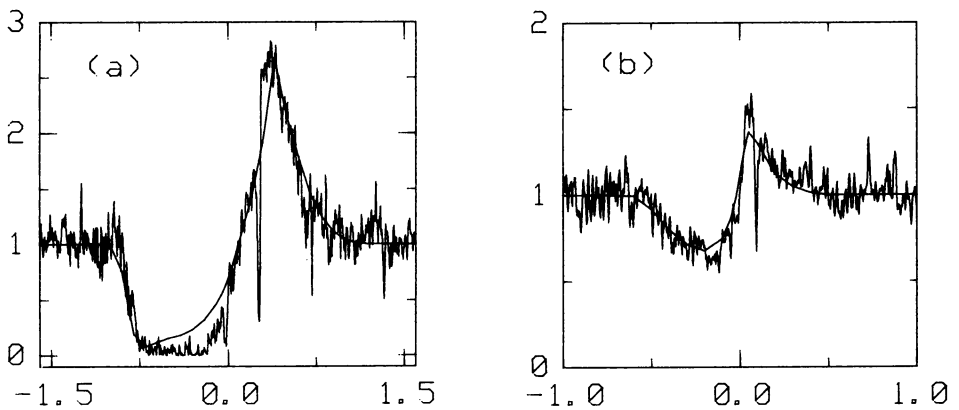

Figure 1. Theoretical profiles computed with the "SEI" method superimposed to the normalized observed profiles of CIV (a) and NIV (b) of the planetary nebula NGC 6826.

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