From Lithium to Uranium: Elemental Tracers of Early Cosmic Evolution
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Chemical evolution of DLA systems

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Abstract. We assume that Damped Lyman-α absorbers are gas rich galaxies on early stages of their evolution, and check this idea on the basis of a spectrophotometric, chemical and dust evolution model. Influence of the dust on the chemical pattern of galaxies is calculated self-consistently according Dwek's (1998) model, where up-to-date dust yields from supernovae, intermediate and low mass stars on their AGB phase are taken into account. We conclude that gas rich galaxies are good candidates on the role of DLA systems.

Keywords. Quasars: absorption lines, galaxies: evolution, dust

1. Introduction

Damped Lyman-α (DLA) systems are a class of QSO absorbers with N(HI)$> 2 \times 10^{20}$ cm^{-2}. They are responsible for the strongest absorption in the spectra of distant quasars, and are traditionally assumed to be progenitors of present day galaxies at early stages of their evolution. There is no general agreement on the nature of DLA galaxies. It is difficult to detect them in emission. To date, it has been possible to identify morphologies of only about 20 galaxies, which presumably give rise to DLA absorption. Among them we see spirals, low surfase brightness and compact dwarf galaxies. And it seems plausible that gas rich galaxies of different types are responsible for DLA absorption. Chemical evolution scenarios developed in several groups also have demonstrated that, within uncertainties of both observational data and evolutionary models, DLA systems may be caused by absorption in gas rich galaxies of different types. But in these scenarios it was implicitly assumed that all trace elements contribute to the absorptions, without separation those which can condense in the solid phase (dust grains). It is known, however, that the presence of dust changes dramatically relative abundances in gas phase due to dust depletion effect, and thus can strongly influence the overall observed pattern of chemical enrichment of galaxies. The amount of dust and their characteristics vary and can differ among galaxies of the same morphological type. This suggests, the rates of dust production and dust destruction must be treated consistently with the overall star formation and chemical history of a galaxy. For this purpose we attemped such a self-consistent description.

2. Dust evolution modeling and abundances of DLAs

During recent years a lot of new observational and theoretical data concerning dust evolution became available. Both dust sources and dust evolution processes have been studied in detail by many groups. A self-consistent description of chemical and dust evolution of the interstellar medium of gas-rich galaxies, based on numerical simulations of the dust formation and destruction processes, was first suggested by Dwek (1998). In this way the evolution of the dust fraction for each depleted heavy element in the galactic ISM may be calculated according the chemical evolution of this element in the interstellar medium. By summing up the dust fractions of all depleted elements, the total dust-to-gas ratio may be derived self-consistently at any stage of galactic evolution.

In our approach of dust evolution in Damped Ly-alpha systems we follow Dwek's recipe. Here we present our numerical model, which allows the simultaneous calculation of the spectrophotometric, chemical and dust evolution of gas-rich galaxies. The model is developed on the basis of the spectrophotometric evolutionary synthesis code $PEGASE.2$ (Fioc & Rocca-Volmerange 1997). The original code has been modified and incorporates all necessary ingredients for the calculation of the chemical and dust evolution, as well as tools to estimate the corresponding influence of dust on heavy element abundances in their gaseous phase. The gas in the ISM is treated as a two phase system (dust and gas). The fraction of a depleted element X which is locked up in the solid state depends on the details of the dust evolution. The main dust evolution processes are taken into account: dust condensation during the SNe ejecta and during mass loss of low and intermediate mass stars on their AGB phase; dust grain growth by accretion onto preexisting dust grains in dense molecular clouds; dust destruction by interstellar shock waves. The evolution of the dust phase of ISM is involved self-consistently and is calculated simultaneously with the spectrophotometric and chemical evolution.

Our model is one-zone and matches several observational constraints, such as integrated colors, nearby template spectra, SNe rates, oxygen gas-phase abundances in the ISM, the gas content, the dust depletion pattern in local ISM. We use the IMF in the form given by Kroupa (2001) and assume a Schmidt-type star formation law. Stellar yields for low and intermediate mass stars are taken from (Marigo 2001), for massive stars evolving as SN type II from (Portinari *et al.* 1998), and for SN type Ia from (Iwamoto *et al.* 1999), respectively. A more detailed description of the model and the first preliminary results were published in (Kasimova & Shchekinov 2004, Kasimova 2004).

DLA systems exhibit a wide scatter of their chemical abundances. Various types of gas-rich galaxies with different histories of star formation and thus different histories of their chemical enrichment may explain this observational fact, but dust corrections are essential in all interpretations. We have developed a self-consistent spectrophotometric, chemical and dust evolution model for gas-rich galaxies on the basis of $PEGASE.2$ code and Dwek (1998) model. Comparing abundances observed in DLA systems over the available redshift range with our simple one-zone model calculations for spiral (from early to late types) and irregular galaxies, we have concluded that these gas-rich galaxies fit reasonably well the DLAs' chemical pattern, and may be considered as DLA absorbers. More complicated galactic evolution models with up-to-date dust yields for SNe stars and intermediate mass stars on their AGB phase (Todini & Ferrara 2001, Gail & Ferrarotti 2005) nevertheless are necessary, and such a work is in progress.

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