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DAMPED LYα SYSTEM TOWARD QSO1854+116 – A NEW TYPE OF ABSORBER?

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SUMMARY: A puzzle of the low-redshift damped Lyα absorption system toward QSO 1854+116 is presented. Problems which conventional intepretation of damped Lyα systems encounters in this case are sketched and a possible explanation, based on transience of the phenomenon, is suggested. It is shown that the detailed Hα tomography can observationally resolve the controversy in the very near future.

1. INTRODUCTION

The damped Lyα (henceforth DLA) absorption systems (those with neutral column density $\log N_{\rm HI} > 20.3$ cm^{-2}) are characterized by optical depth at the Lyman limit so large that hydrogen is predominantly neutral (Weymann *et al.* 1981). common modern interpretation of DLA systems identifies them with the *disks* of young/proto-galaxies (e.g. Wolfe *et al.* 1986; Lanzetta *et al.* 1989). In several instances, this has been observationally confirmed by detection of emission coincident in redshift with the damped line in close vicinity of the line-of-sight toward the QSO (e.g. Møller and Warren 1993), but these case are still very rare, and much effort is currently invested in finding and analyzing similar cases. In that respect, particularly important are DLA systems to be found (via space-based spectroscopy) at low redshift, for which the complete catalog of all objects in the QSO field can be expected. This, however, is not an easy enterprise, since the redshift distribution of DLA systems is such that best fit average number of such systems per unit redshift at the present epoch is only about (Storrie-Lombardi *et al.* 1996)

$$\left(\frac{d\mathcal{N}}{dz}\right)_0^{\rm DLA} = 0.04^{+0.03}_{-0.02}. \qquad (1)$$

This question has become particularly interesting since the recent realization that most of the low-redshift ($z < 1$) galaxies are surrounded by large gaseous envelopes with covering factor close to unity, causing a significant fraction of observed low-z absorption lines in all column density regimes (Lanzetta *et al.* 1995; Chen *et al.* 1998). The anticorrelation between the observed neutral hydrogen equivalent width W (and corresponding column density $N_{\rm HI}$) of a particular low-z absorption system and impact parameter ρ of the line-of-sight relative to the galaxy coincident in redshift space with that absorber has been quantified on the statistical basis by Chen *et al.* (1998) and can be written as

$$\log\left(\frac{N_{\rm HI}}{10^{20}\ {\rm cm}^{-2}}\right) = -\,A\log\left(\frac{\rho}{10\ {\rm kpc}}\right) + \\ + B\log\left(\frac{L_B}{L_{B_*}}\right) + C, \tag{2}$$

where L_B is galaxy B-band luminosity (compared to standard Schechter B-band luminosity L_{B_*}), and A, B and C are constants, which are equal to (with 1σ uncertainties)

$$A = 5.33 \pm 0.50, \tag{3}$$

$$B = 2.19 \pm 0.55, \tag{4}$$

and

$$C = 1.09 \pm 0.90. \tag{5}$$

These results are in accordance with the previous and less detailed survey of Lanzetta *et al.* (1995), where the corresponding value to the Eq. (3) is $A' = 5.3$ (no uncertainties quoted). The information about gaseous galactic haloes contained in the Eq. (2) presents a powerful tool for investigation of the cosmic gaseous budget. What is important from our current point of view is that this relation is supposed to hold for a very wide range of column densities, including those which lie in the DLA region.

In this work, however, we would like to point to a particular case of the $z = 0.16$ DLA absorber toward QSO 1854+116, investigated by Lanzetta *et al.* (1997). At a first glance, this is an excellent test-case for hypotheses concerning origin of the QSO absorption system - low redshift, rather clear field, etc. However, in view of its strange properties, we may ask whether it belongs to a "tail" of the known (galactic disk/halo) population of absorbers, or to a completely new type.

2. PROBLEMS WITH CONVENTIONAL INTERPRETATION

This object was studied extensively by Lanzetta *et al.* (1997). It is located at exact redshift of $z = 0.163770 \pm 0.00054$, thus being the lowest-redshift confirmed DLA system known (but see Petitjean *et al.* 1996; Miller *et al.* 1999), and has neutral hydrogen column density of $\log N = 19.81 \pm 0.04$ cm^{-2}. Presumed absorber is nearby S0 galaxy with impact parameter of only $\rho = 16.6\ h^{-1}$ kpc, which is coincident in redshift space with the damped Lyα absorption up to velocity splitting of 74 ± 14 km s^{-1}. Galaxy coordinate offsets in Right Ascension and Declination are 8.9 and 2.0 arc sec respectively. Now, the morphological type of the suspected absorber does not present problem in itself, since, the absorption properties of galaxies are largely independent of the morphological type (Yahata *et al.* 1999).

The same conclusion does not apply to the fact that it is a subluminous galaxy, with $L_B = 0.4\,L_{B_*}$. The large quantity of absorbing gas is, thus, incompatible with the general relation linking luminosity, impact parameter and neutral column density of gaseous halo given in the Eq. (2). The column density predicted for this absorber from the Eq. (2) is about $\log N_{\rm HI} = 17.4$ cm^{-2} (for Hubble parameter $h = 0.5$), more than two orders of magnitude less than what is actually observed. Even more disturbing is the inference drawn from Lanzetta *et al.* (1997) Hα data, that the absorbing material *does not participate in the rotation of the galactic disk*. If that is correct, the consequences for the halo models of Lyα absorbers are serious.

We assume that the different sense of rotation of the absorber (as established by the Hα observations of rather low sensitivity) precludes the possibility that absorption arises in extended galactic *disk*. We hereby suggest that DLAS toward 0850+440 is a special kind of absorber arising when the line-of-sight toward a QSO passes through regions of transiently enhanced density of cold, photoionized phase in the haloes of normal galaxies. This is not unnatural, especially when we consider long history of the galactic (or protogalactic) halo hypothesis for the origin of the QSO absorption line systems (e.g. Bahcall and Spitzer 1969; Lake 1988).

Admittedly speculative, this idea deserves further investigation since not only more light would be shed on the nature of low-redshift absorption at the high-column density end of the CDDF, but, if correct, it would offer a unique opportunity to discern what physical processes are dominant in the cloud destruction: inherent instabilities (Kelvin-Helmholtz shredding, Jeans collapse, and others) or collisions. At present, it is not possible to reach an empirical conclusion on this issue.

3. DISCUSSION: A TRANSIENT PHENOMENON?

Gaseous haloes of luminous galaxies necessary to account for the observed fraction of Lyα (and metal-line) absorption systems would be highly collisional systems. Discussions of cloud-cloud collisions in different frameworks can be found in Mo (1994), Walker (1998). From time to time in a halo, we should expect a buildup of column density by shock compression along the interface of colliding clouds.

Such "hot spots" are natural consequence of the two-phase models of halo cooling (Mo and Miralda-Escudé 1996). The probability of detecting such a transient enhancement strongly depends on the typical parameters of cold clouds and microphysics of their formation, but we might get a rough estimate in the following way. The collisional time scale for clouds can be written as (e.g. Mo 1994)

$$t_{\rm col} = 10^9\left(\frac{R_{\rm max}}{100\ {\rm kpc}}\right)\left(\frac{T_h}{10^6\ {\rm K}}\right)^{-\frac{1}{2}}\langle\kappa\rangle^{-1}\ {\rm yrs.} \tag{6}$$

In this equation, $R_{\rm max}$ denotes the maximal extent of the spherical halo, T_h is the temperature of the hot plasma component (similar to the virial temperature for galaxy of given mass), and κ is the covering factor of the cold clouds averaged over (0, $R_{\rm max}$) interval. Total collisional cross-section in an individual halo can then be written as

$$\sigma_c = N_{\rm cl} \frac{\Delta t}{t_{\rm col}} S, \tag{7}$$

where Δt is the average duration of collisionally enhanced conditions, $N_{\rm cl}$ the total number of clouds in the halo, and $S \sim \pi R_{\rm cl}^2$ is the cross-section of each collision area, approximately equal to the cross-section of each individual cloud. Natural timescale for the duration of collision itself is given as $\Delta t = R_{\rm cl}/v_s$, where v_s is the shock speed, i.e. it is equal to the time for the shock generated by the collision to propagate across the cloud of size $R_{\rm cl}$. After we get better hold on the physics of collision processes themselves, we shall be able to use Poissonian statistics to estimate the number of haloes intercepted in such way that the line-of-sight passes through a "hot spot".

One of the relevant prospects for improvement of our knowledge on this, and other low-redshift DLA absorption systems is the detailed Hα observations with high surface-brightness sensitivity. As shown elsewhere by the present author and collaborators, such surveys, using either low-resolution spectroscopy, or Fabry-Perot imaging, are appropriate at the present technological level up to $z \sim 0.8$ (Ćirković *et al.* 1999). For the specific case of the DLA system toward QSO 1854+116, high sensitivity Hα mapping of the invisible "bridge" between the absorber and the galaxy could present the *experimentum crucis* for interpretation of the low-z DLA systems. In the same time, it will check the possibility that fuzzy filaments noted in this (rather clear, it should be emphasized) QSO field are physically connected with the absorption system. If spectroscopical approach is employed, the velocity map sensitive at $\Delta v \sim 50$ km s^{-1} would immediately reveal whether the chaotic motion of the halo clouds and their collision is responsible for the velocity splitting seen between absorption and emission centroids. It would also be noted that the hypothesis that this object falls into the tail of "normal" generic distribution of neutral gas around galaxies, immediately suggests uncomfortably large baryonic mass contained in the absorbing gas (which is the commonplace of all models in which clumping is less important). In short, investigations of recombination emission from this and possible other similar cases should shed much light not only on the underlying physics of the structure of haloes of normal galaxies at later epochs, but at the cosmological distribution of baryons as well.

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REFERENCES

Bahcall, J.N. and Spitzer, L.Jr.: 1969, *Astrophys. J.*, **156**, L63.

Chen, H.-W., Lanzetta, K.M., Webb, J.K. and Barcons, X.: 1998, *Astrophys. J.*, **498**, 77.

Ćirković, M.M., Bland-Hawthorn, J. and Samurović, S.: 1999, *Month. Not. Royal Astron. Soc.*, **306**, L15.

Lake, G.: 1988, *Astrophys. J.*, **327**, 99.

Lanzetta, K.M., Wolfe, A.M. and Turnshek, D.A.: 1989, *Astrophys. J.*, **344**, 277.

Lanzetta, K.M., Bowen, D.V., Tytler, D. and Webb, J.K.: 1995, *Astrophys. J.*, **442**, 538.

Lanzetta, K.M., Wolfe, A.M., Altan, H. *et al.*: 1997, *Astron. J.*, **114**, 1337.

Miller, E.D. Knezek, P.M. and Bregman, J.N.: 1999, *Astrophys. J.*, **510**, L95.

Mo, H.J.: 1994, *Month. Not. Royal Astron. Soc.*, **269**, L49.

Mo, H.J. and Miralda-Escudé, J.: 1996, *Astrophys. J.*, **469**, 589.

Møller, P. and Warren, S.J.: 1993, *Astron. Astrophys.*, **270**, 43.

Petitjean, P., Théodore, B., Smette, A. and Lespine, Y.: 1996, *Astron. Astrophys.*, **313**, L25.

Storrie-Lombardi, L.J., Irwin, M.J. and McMahon, R.G.: 1996, *Month. Not. Royal Astron. Soc.*, **282**, 1330.

Walker, M.: 1998, *Month. Not. Royal Astron. Soc.*, in press (preprint astro-ph/9807236)

Weymann, R.J., Carswell, R.F. and Smith, M.G.: 1981, *Ann. Rev. Astron. Astrophys.*, **19**, 41.

Wolfe, A.M., Turnshek, D.A., Smith, H.E. and Cohen, R.D.: 1986, *Astrophys. J. Suppl.*, **61**, 249.

Yahata, N., Lanzetta, K.M., Webb, J.K. *et al.*: 2000, in preparation.

ПРИГУШЕНИ LYα СИСТЕМ У ПРАВЦУ QSO 1854+116 – НОВА ВРСТА АБСОРБЕРА?

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Размотрена је загонетка пригушеног Lyα апсорпционог система у правцу квазара QSO 1854+116. У кратким цртама су скицирани проблеми на које у овом случају наилази уобичајена интерпретација пригушених Lyα система, и сугерисано могуће објашњење, засновано на пролазном карактеру овог феномена. Показује се да ће детаљна Hα томографија бити у стању да кроз посматрања разреши ову загонетку у веома скорој будућности.