SPECTRA OF BINARY SYSTEMS USING CLOUDY

SEISMIC

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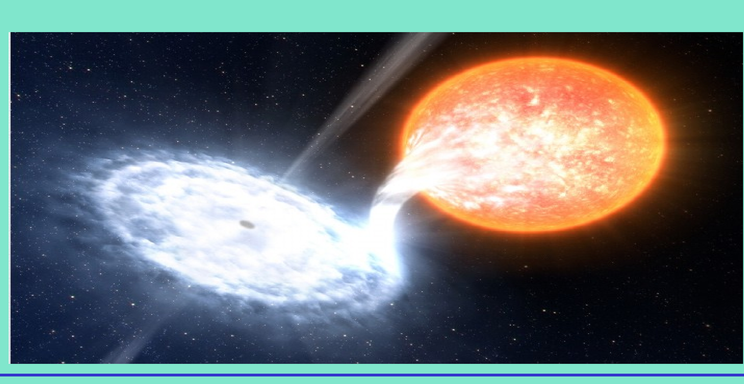
Abstract

We present the results obtained after performing CLOUDY simulations for an X-ray binary source 4U 1820-30. We have simulated absorption features around O VII and Ne IX lines using different inputs. The physical interpretations for each simulation is discussed.

Introduction

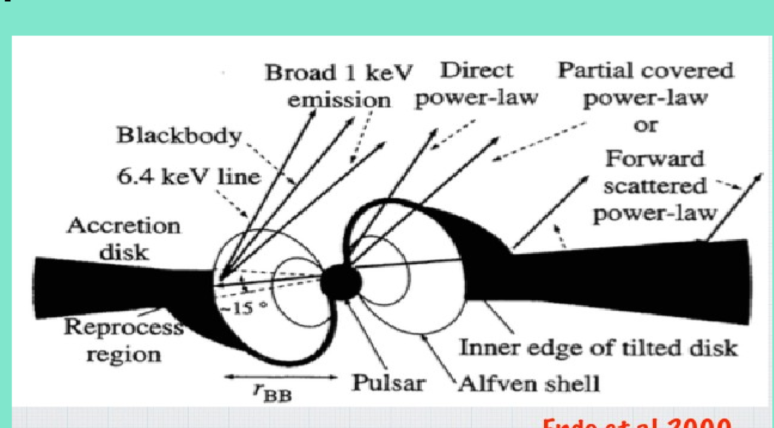
X-ray Binary

X-ray binaries are the brightest X-ray sources in the sky that emit predominantly in X-rays Luminosity $(L_X) \sim 10^{33} - 10^{38}\ ergs/s$. As the name suggests, it consists of two stars that are gravitationally bound to each other and revolving around a common centre of mass. One of the star in these binaries is a compact object that accretes matter from a normal or white dwarf, known as a companion or secondary star. The figure below shows an artist impression for an X-ray binary. Roche lobe overflow is the dominant mode of accretion in LMXBs. The matter that passes the inner Lagrangian point has a high specific angular momentum hence acts like a nozzle. The matter cannot reach the surface until most of its angular momentum is removed. Thus, accretion disk behaves as an efficient 'machine' for slowly lowering material in the gravitational potential of an accreting object.



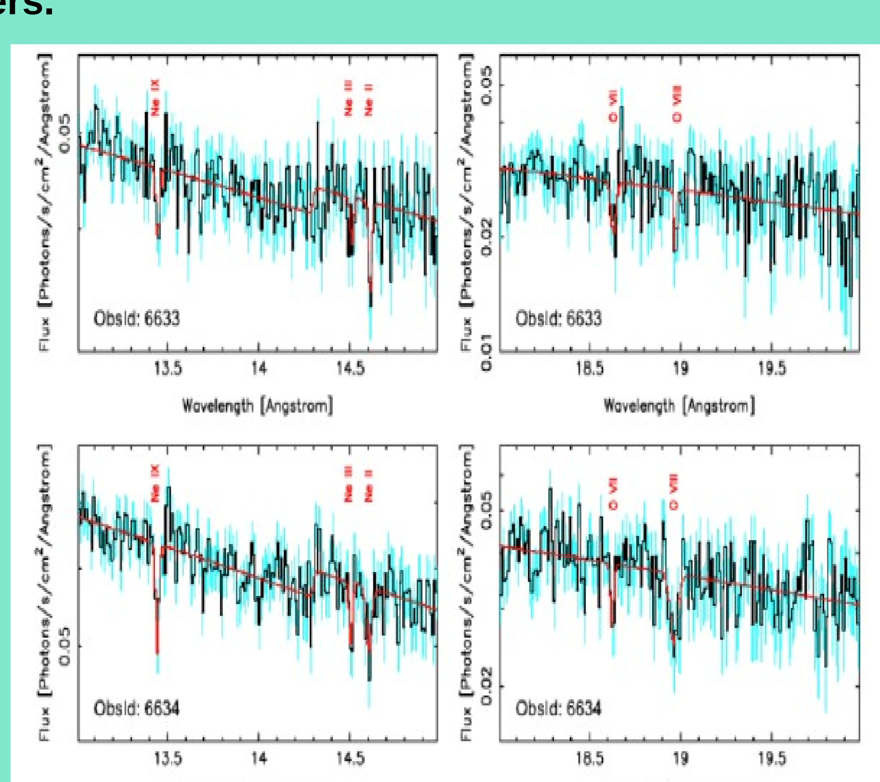
X-ray Spectra

There are several mechanisms by which X-ray binaries generate and modify X-ray emission and may radiate as a result of more than one process. These include blackbody radiation, bremsstrahlung, inverse Compton scattering, radiative atomic transitions.



Motivation

4U 1820-30 is an ultra-compact binary containing a white dwarf star located in the Globular cluster NGC 6624. It exhibits an orbital period of 11.4 minutes. Persistent luminosity measured for this source was $L_X = 10^{37}\ ergs/s$ and this yield the mass accretion rate of $10^{-9} M/year$ (Cumming, 2003). A unique feature of this source is its X-ray spectrum which shows absorption features around line energies O VII (0.569 keV), OVIII (0.653 keV) and Ne IX (0.915 keV). The following spectrum is obtained using Chandra data (Cackett et al. 2008). Using CLOUDY , we aim to understand the physical conditions around the compact object by modelling these absorption features with physical parameters.



Methodology adopted:

Simulating Absorption lines by:
1) Varying Ionization parameter 2) Varying 'hden' Average density
3) Varying abundances & 4) Varying Column Density

Results

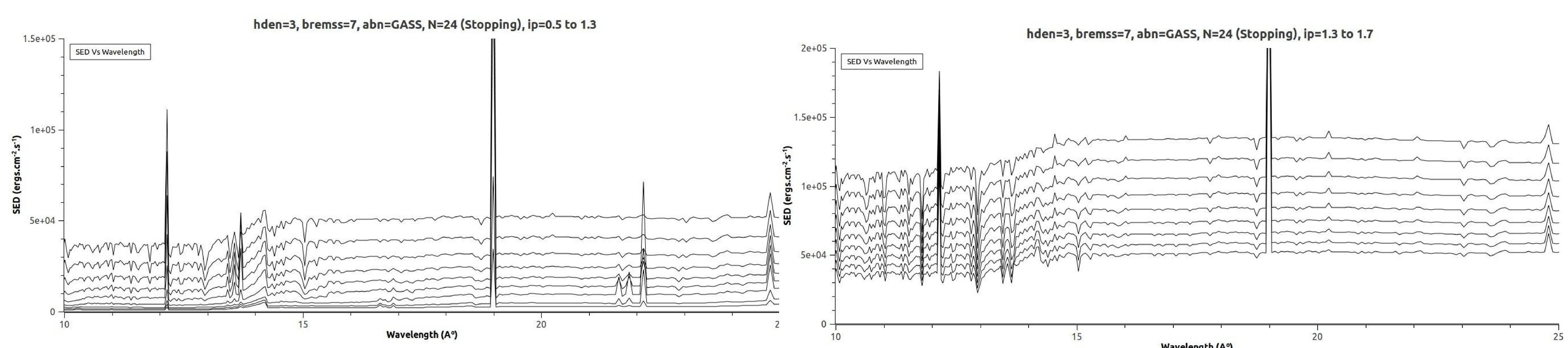
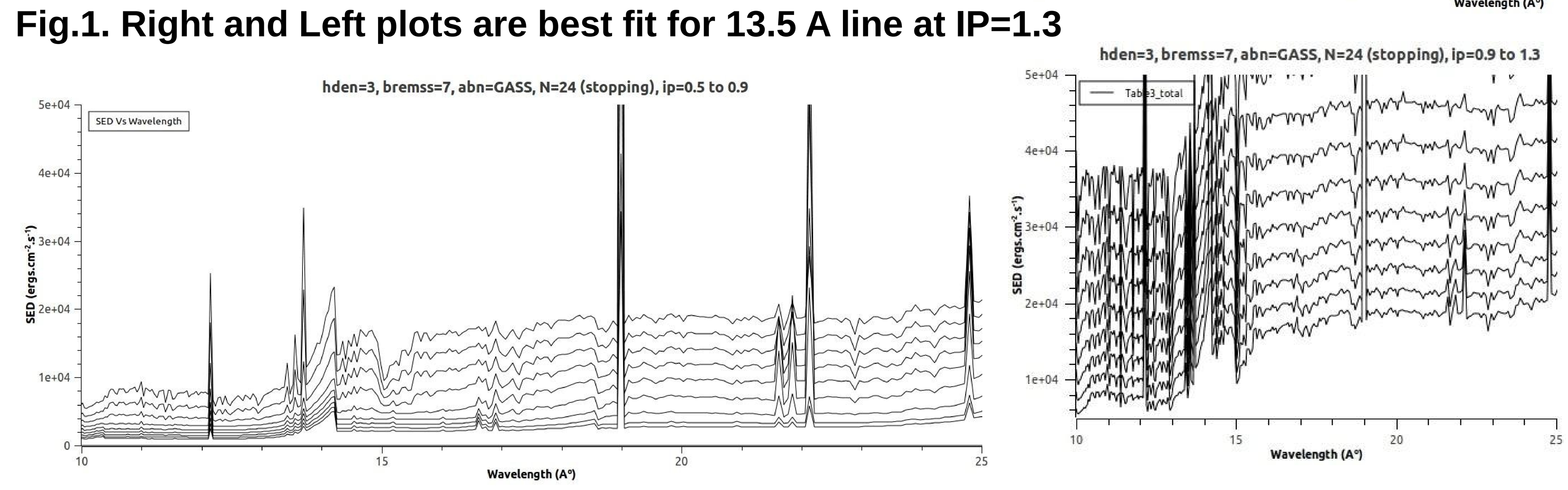


Fig.1. Right and Left plots are best fit for 13.5 A line at IP=1.3



$$U \equiv \frac{Q(H)}{4\pi r_0^2 n(H)\, c} \equiv \frac{\Phi(H)}{n(H)\, c}$$

Fig.2. Right and Left side plots are best fit for 21.6 A line at IP=0.9

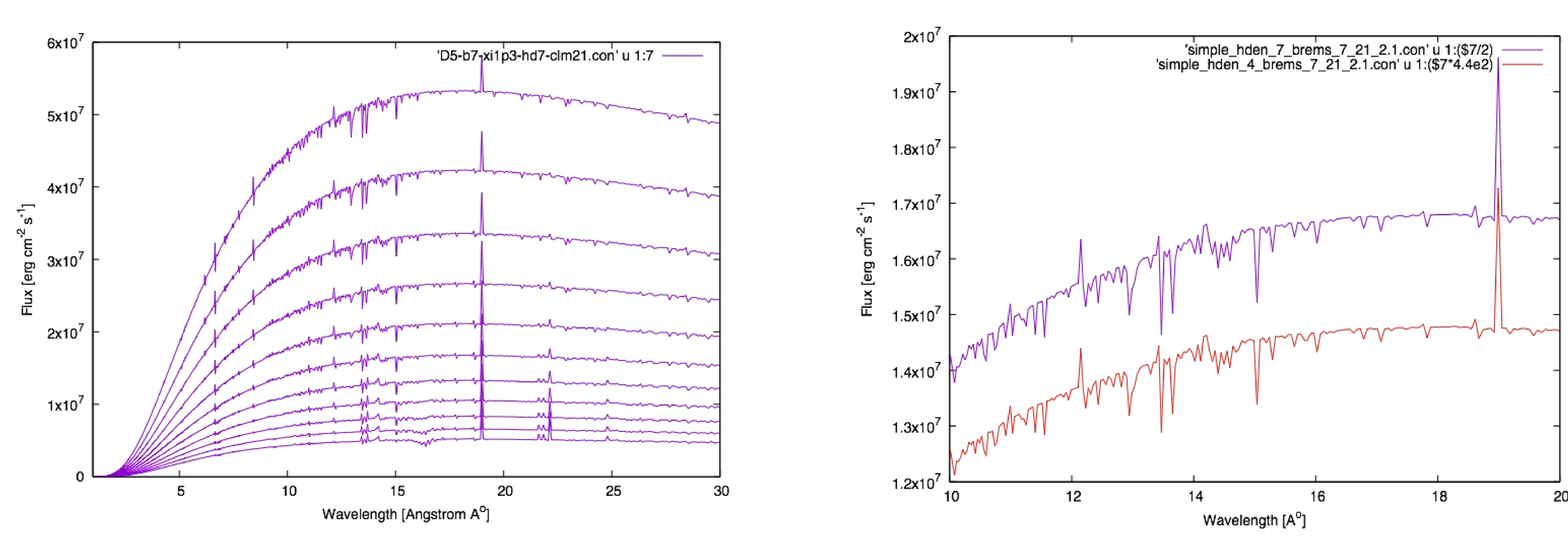


Fig.3. Comparison of Absorption depths with hden=7 and 4 at nH=10^21 cm^{-2}

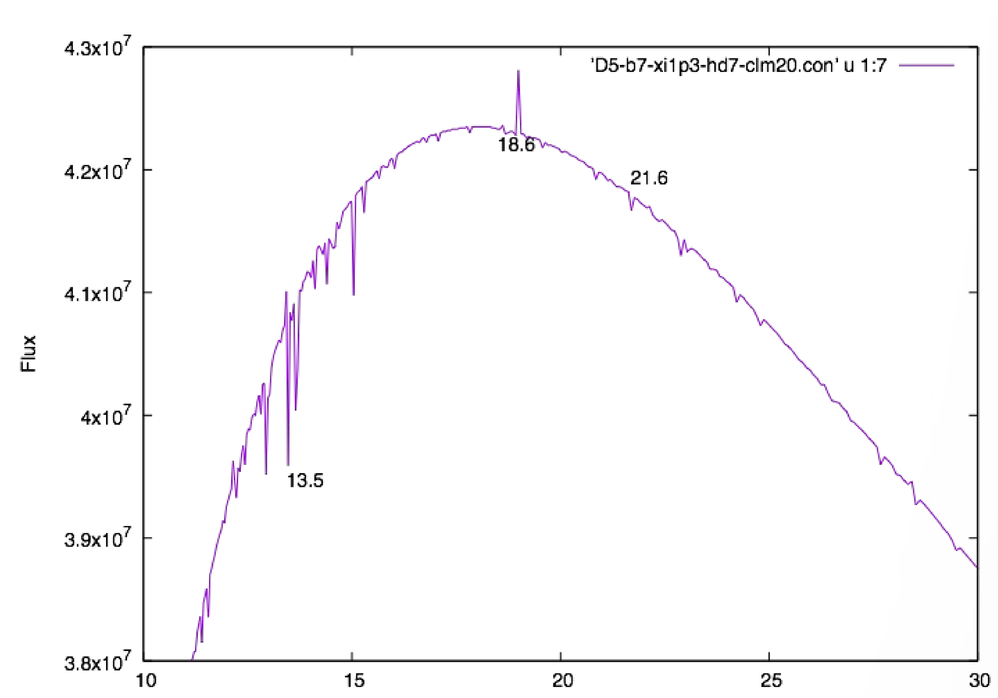


Fig.4. Observed aborobed spectral lines at given wavelength

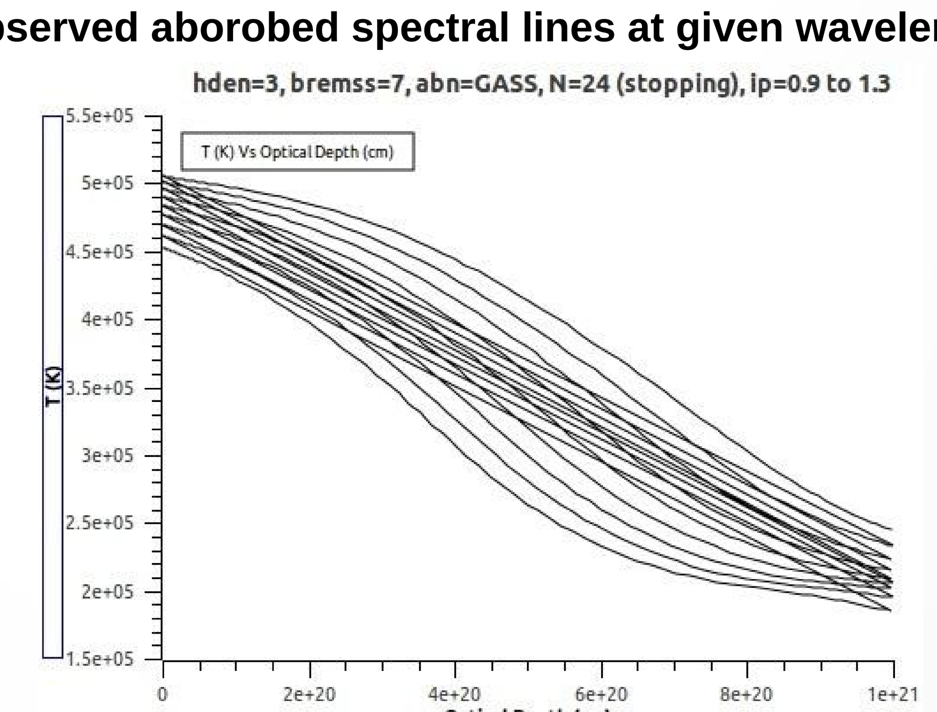


Fig.5. Variation of optical depth with temperature:

a) At higher values of IP, T behaves isothermally at all the values of optical depth which suggests that the ionisation is uniform throughout the cloud.

b) At lower values of IP, T is higher close to the star surface and decreases as we move across the cloud.

c) For IP values in the range of 0.9-1.0, the straight line behavour is yet not understood.

- **Hden, Abundances and Geometry are not influencing parameters for our system**
- **'Grid' works efficiently, 'optimize made complicacies**
- **Needs to work more, to have an estimate of 'r_{0}' or to fix 'nR^{2}'**
- **From fig.1 Right and Left side plot shows best fit for 13.5 A line at IP=1.3**
- **From fig.2 Right and left side plot shows best fit for 21.6 A line at IP=0.9**

Discussion

- **The rate at which photo ionization occurs for a given nR^2 goes from negative to positive (more isothermal) through 0 as the Ionization Parameter changes from lower to higher numerical values (ref. The combined plot between T vs Optical depth).**
- **Need to do more fitting using better optimizations, understanding the physical /chemical process therein in the cloud.**

Future plan

- **Needs more work to fix either the Column Density(n) or the separation between the mean of radiation producing star and the plasma(R).**

References

- Cackett et al., 2003
- Cackett et al., 2008
- Cumming et. al., 2003
- Endo et al., 2000
- Gary J Ferland & D E Osterbrock : Astrophysics of Gaseous nebulae and active galactic nuclei

Acknowledgments

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