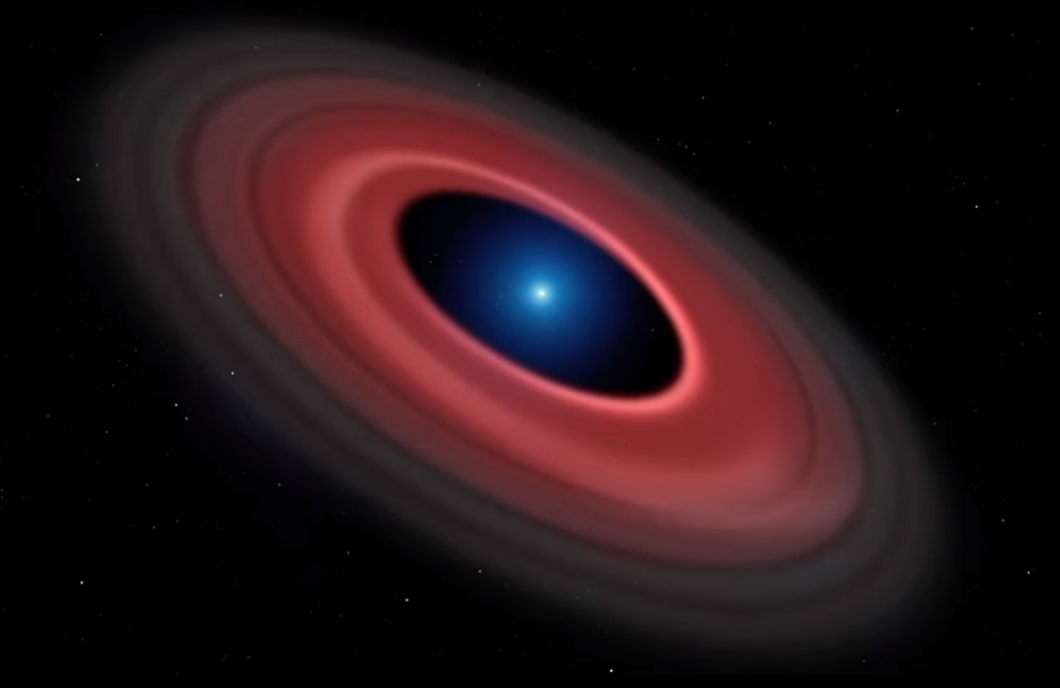
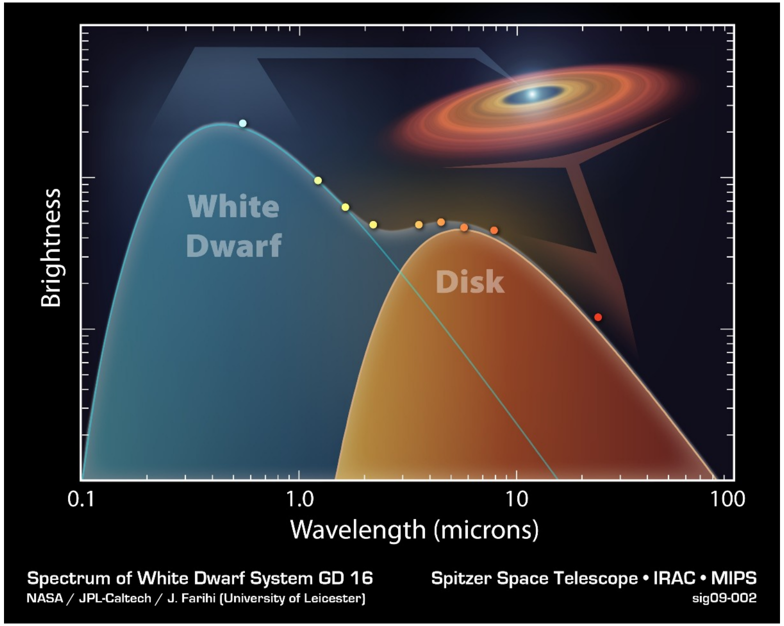
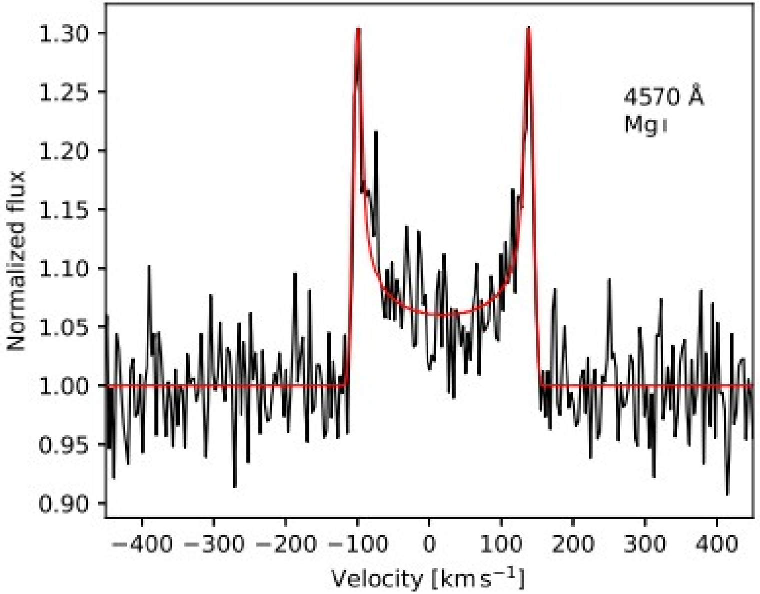
A General framework for the chemical characterization of gaseous discs around white dwarfs with Cloudy



Felipe Lagos-Vilches, Boris T. Gänsicke, C. J. Manser, C. Morisset, N. P. Gentile Fusillo,
Odette Toloza, S. H. Ramirez, M. R. Schreiber

Debris discs around white dwarfs (WD) are detected via infrared (IR) excess and/or double-peak line emission





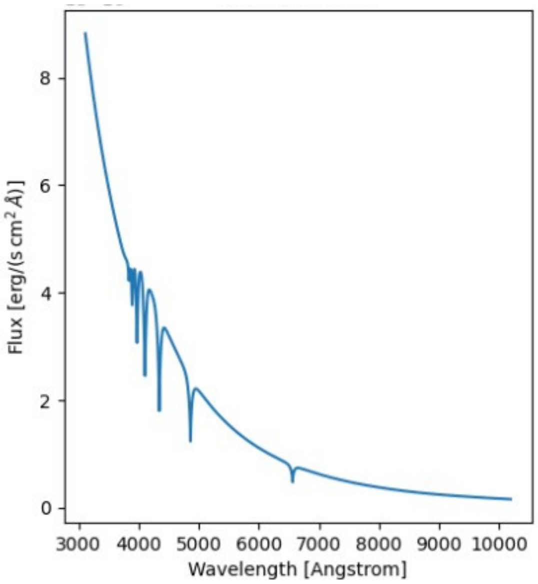
Gentile-Fusillo et al. 2021

Total occurence rate=1-3%

Relative to WD+dusty discs = $4\pm\frac{4}{2}$

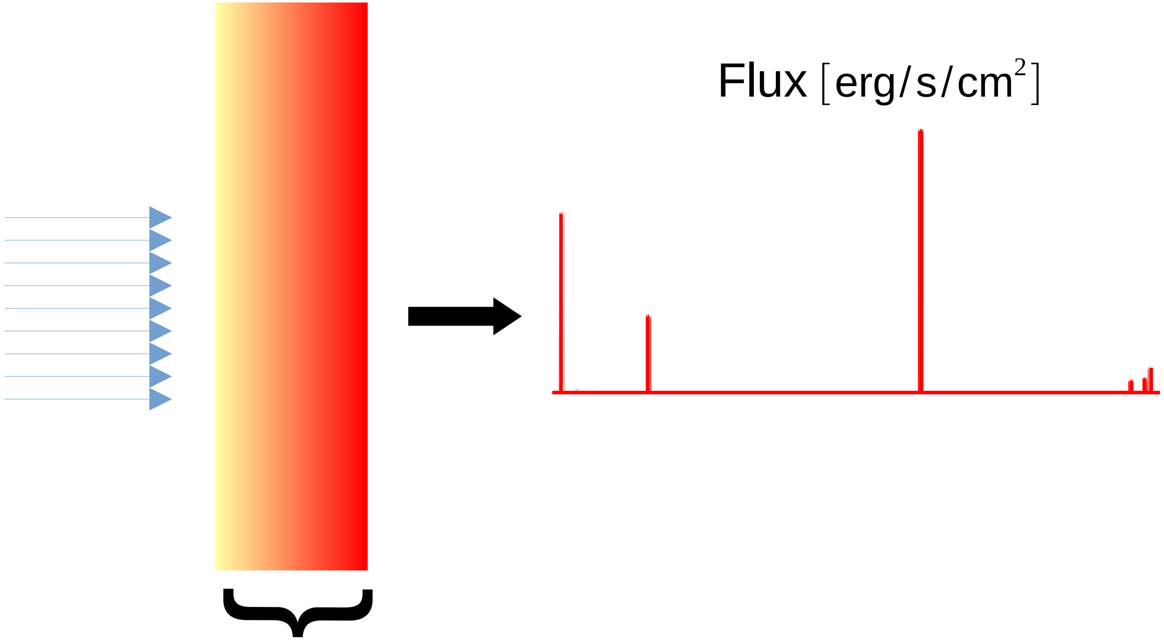
Farihi et al. 2009; Girven et al. 2011; Rocchetto et al. 2015; Rebassa-Mansergas et al. 2019; Wilson et al. 2019 , Manser et al. 2020

How Cloudy works: A general view



Radiation source

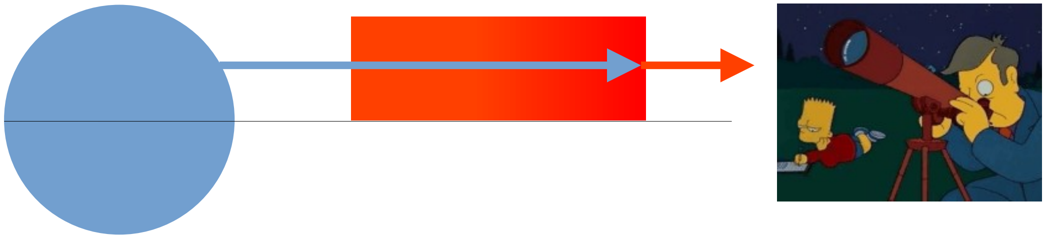
* F_{total}



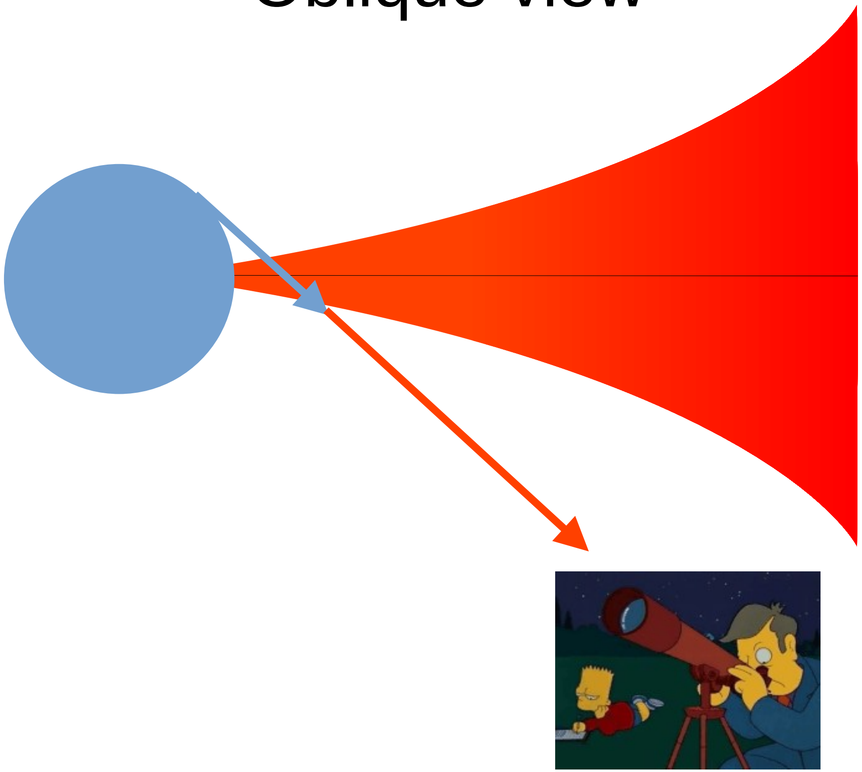
Thickness
+
Composition

How Cloudy works: Setting the Intensity and thickness of the parcel

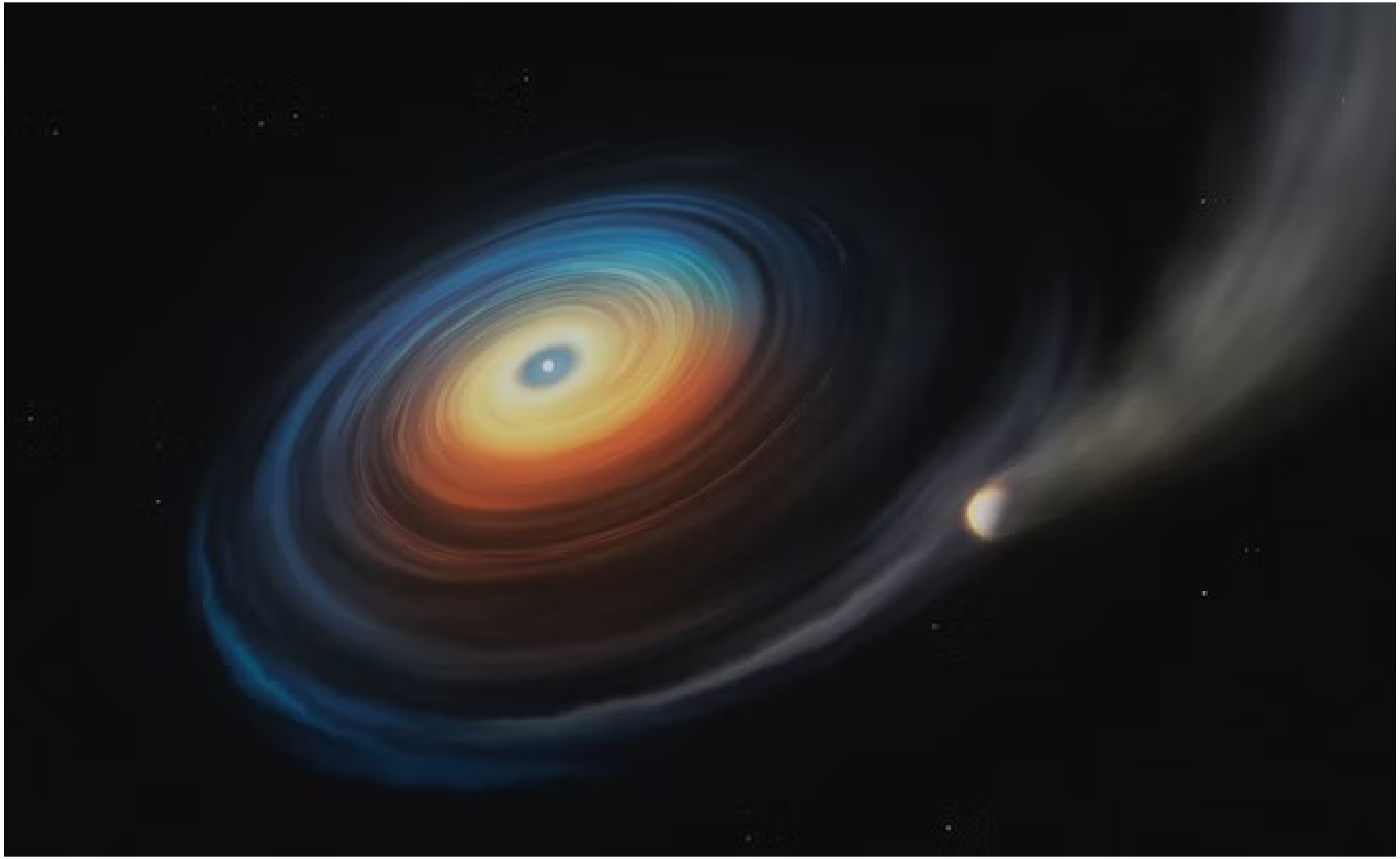
Edge-on view



Oblique view

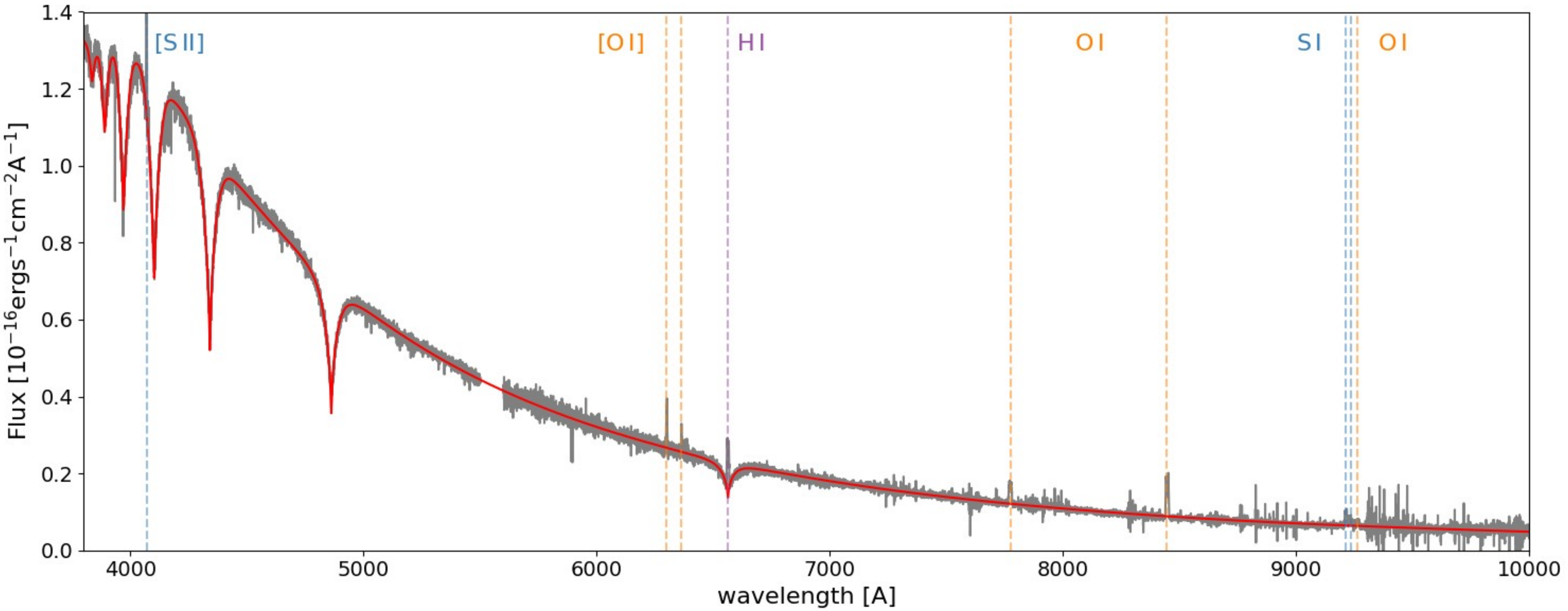


Testing the machinery: Benchmark with WDJ0914+1914

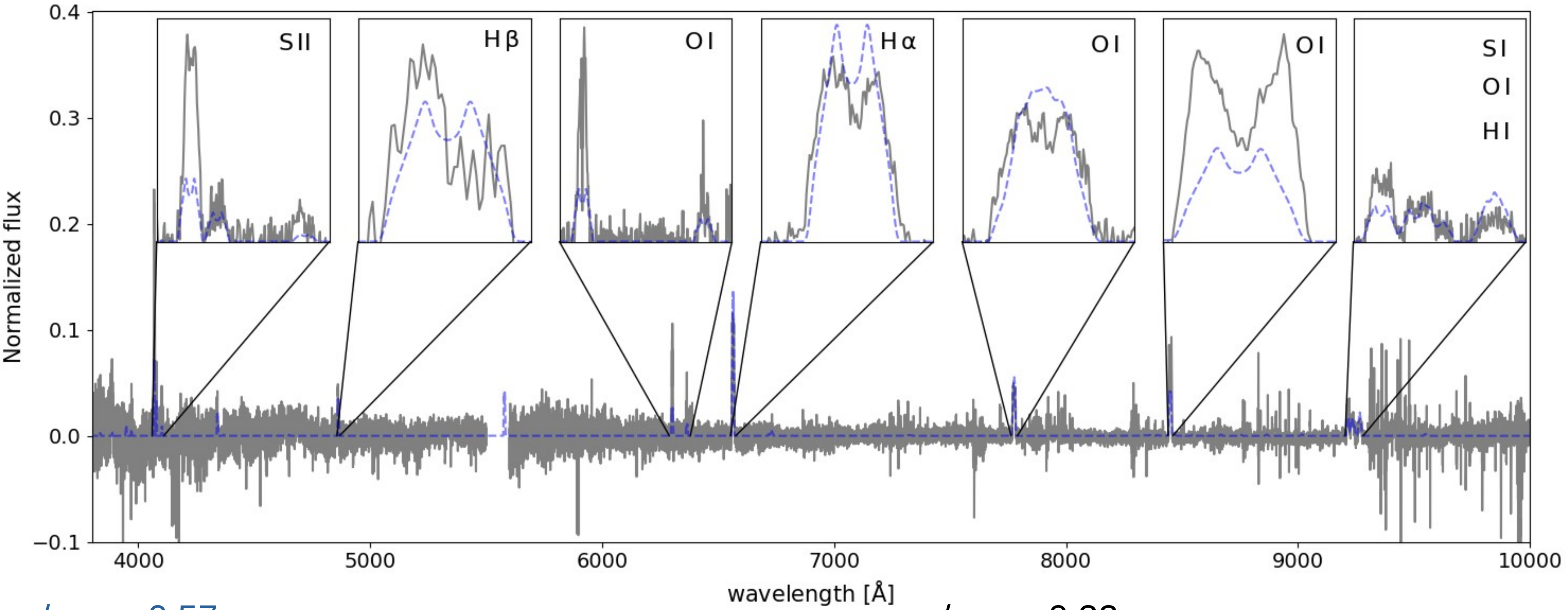


Gansicke et al. 2019 ESO/M. Kornmesser

Line identification: nine lines of sulphur, oxygen and hydrogen



Cylindrical setup: Observed and model lines ratios differ on average by a factor of **2**

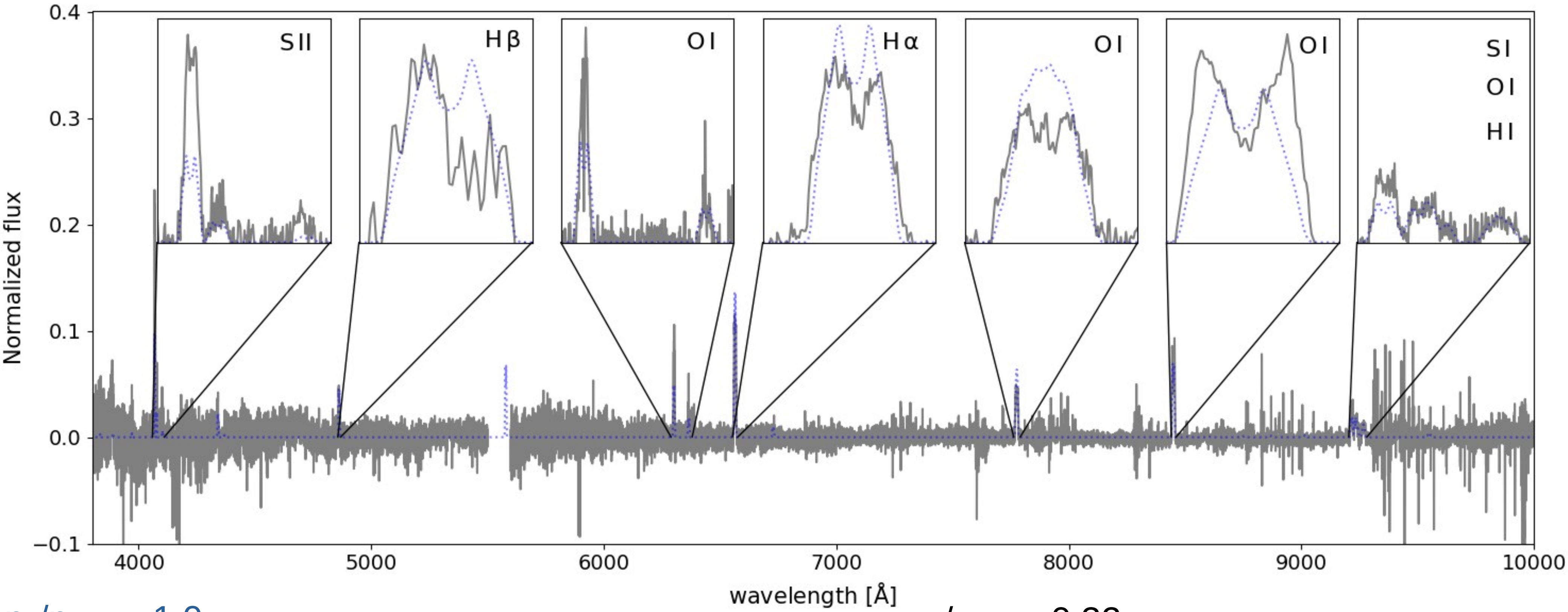


n_S/n_O =0.57
n_O/n_H =0.07
n_S/n_H =0.04
ρ_{tot} =$10^{-12.1}$ g/cm^3

n_S/n_O =0.32
n_O/n_H =2.0 (1-3.8)
n_S/n_H =0.6 (0.3-1.2)
ρ_{tot} =$10^{-11.3}$ g/cm^3

Gansicke et al. 2019

Flared setup: Observed and model lines ratios differ on average by a factor of **1.4**

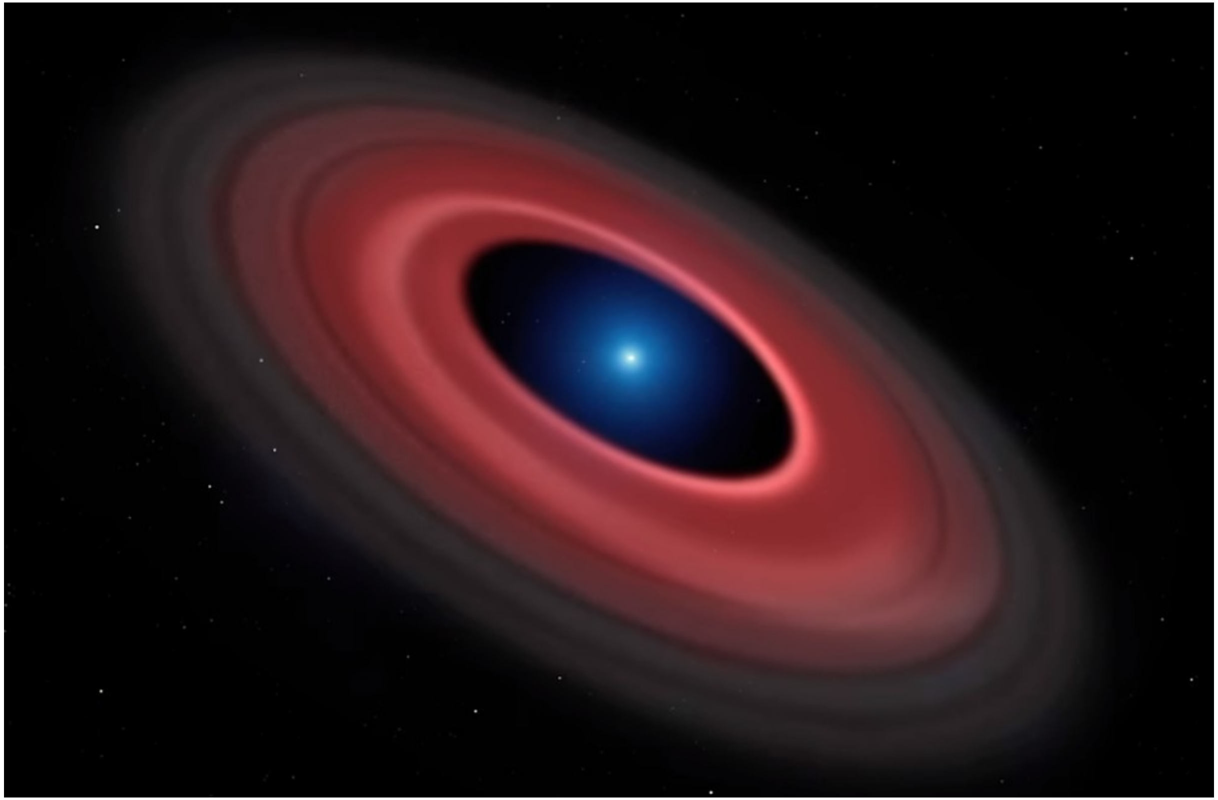


n_S/n_O =1.0
n_O/n_H =0.2
n_S/n_H =0.2
ρ_{tot} = $10^{-11.8}$ g/cm^3

n_S/n_O =0.32
n_O/n_H =2.0 (1-3.8)
n_S/n_H =0.6 (0.3-1.2)
ρ_{tot} =$10^{-11.3}$ g/cm^3

Gansicke et al. 2019

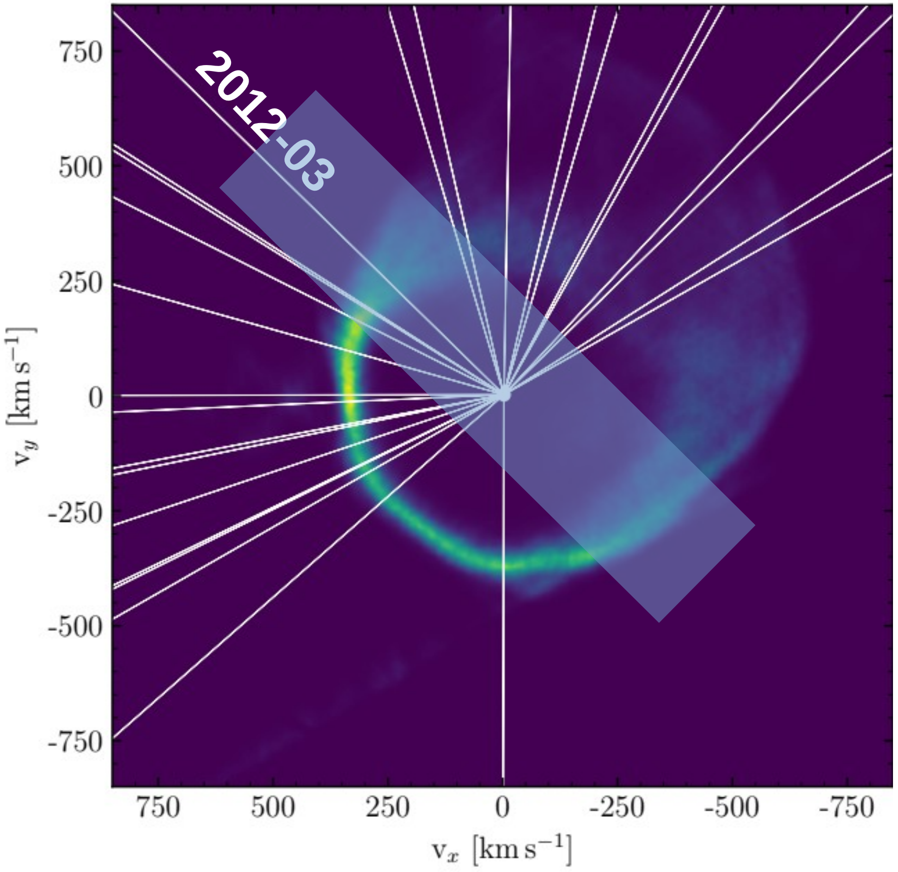
Testing the machinery: visiting the first gaseous disc discovered around a white dwarf- SDSS 1228+1040

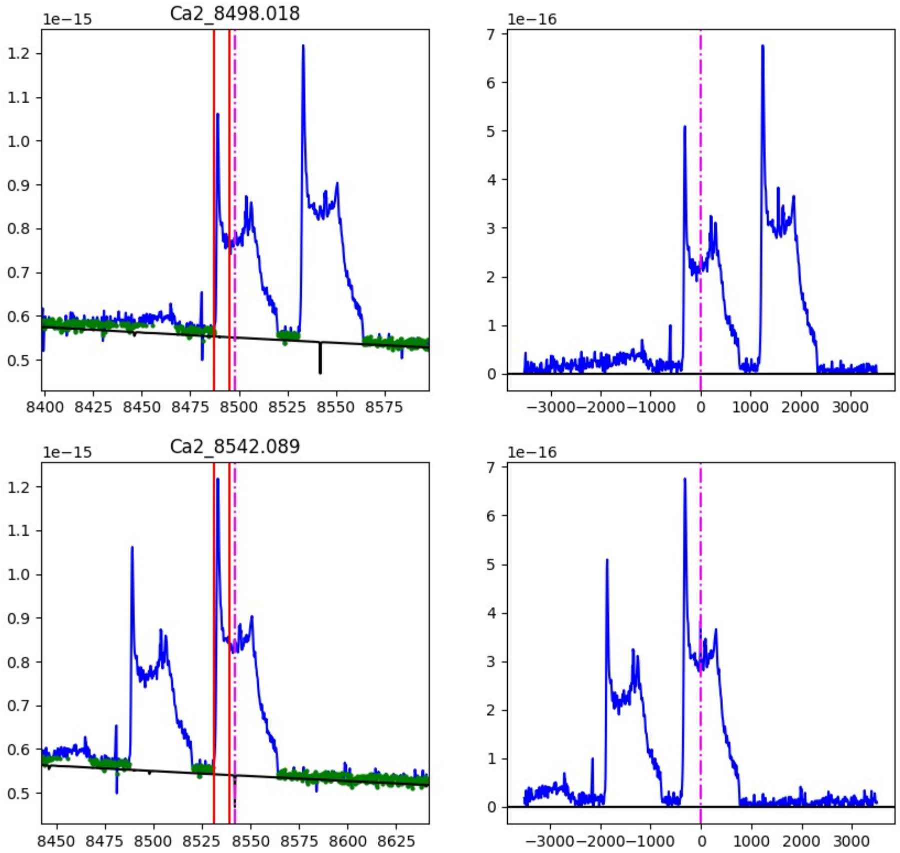


Gansicke et al. 2006

Mark Garlick

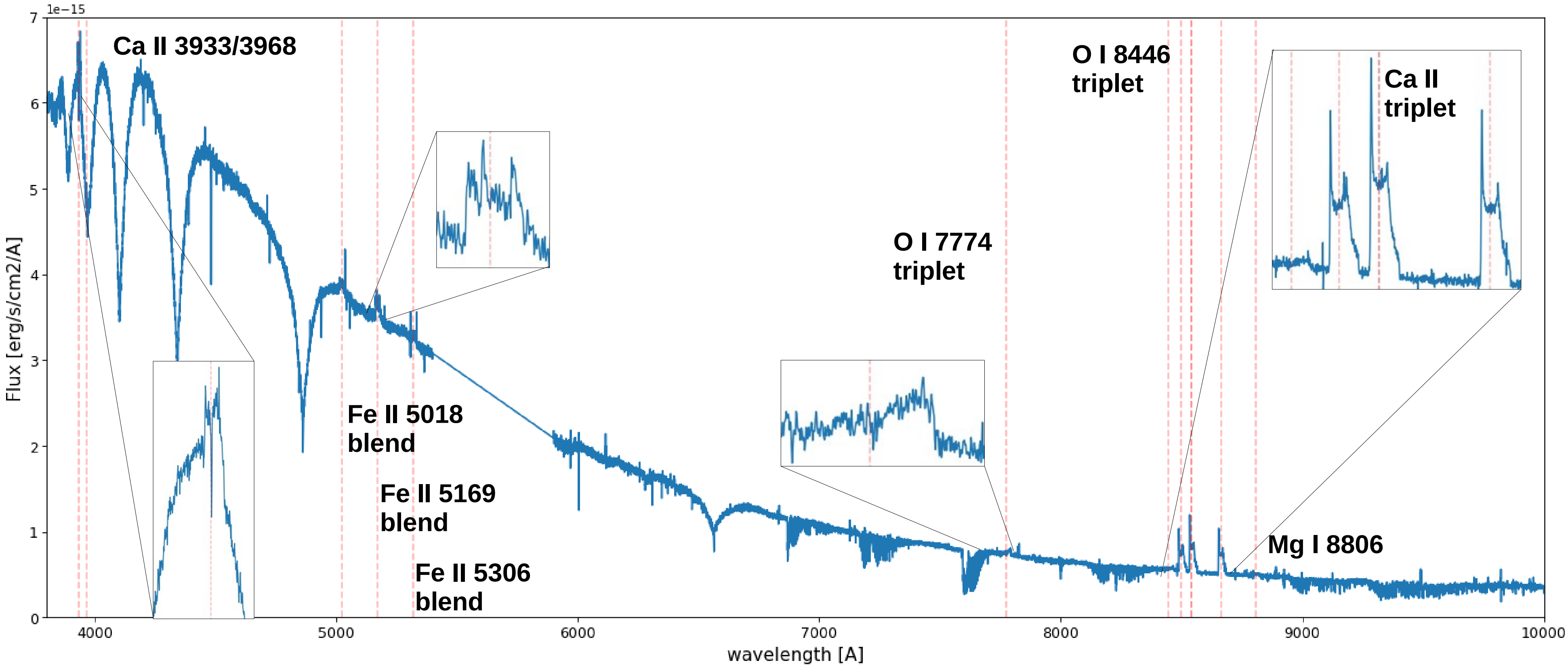
Material in eccentric discs is not radially symmetic, which is incompatible with Cloudy



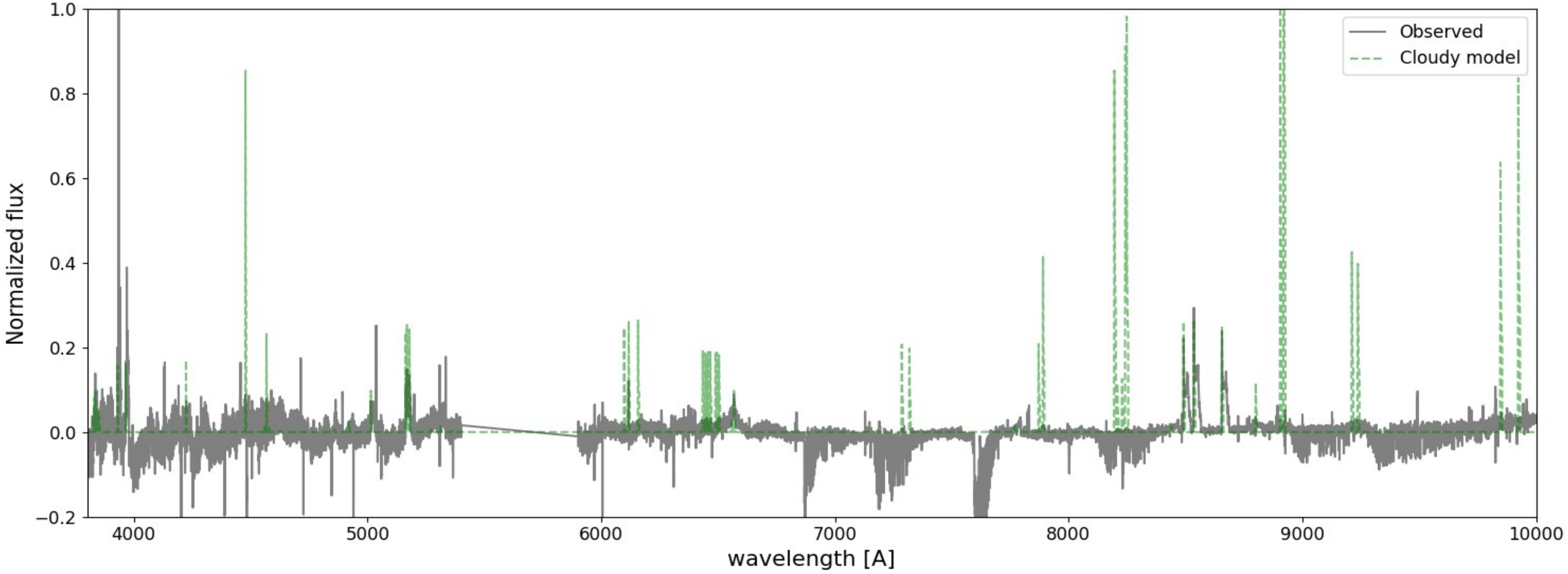


Courtesy of C. Manser

Spectrum of SDSS 1228 for epoch 2012-03



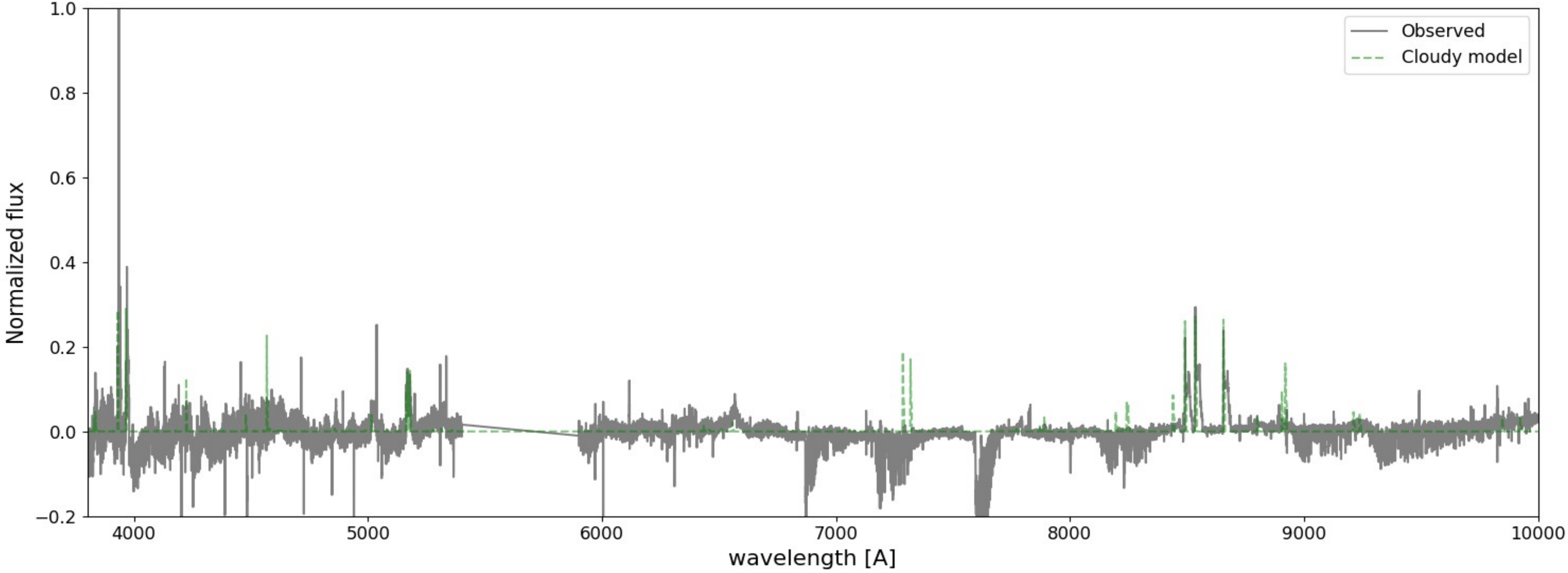
Cloudy Lines ratios differ on average by a factor of **1.8** with respect to observations



$\log_{10}(n_H)=10$
$n_O/n_H = 1$
$n_{Mg}/n_H = 10$
$n_{Ca}/n_H = 100$
$n_{Fe}/n_H = 0.01$

$\rho_{tot} = 10^{-11.8}$ g/cm^3
$n_O/n_{Ca} = 0.01$
$n_{Mg}/n_{Ca} = 0.1$
$n_{Fe}/n_{Ca} = 0.001$

Cloudy Lines ratios differ on average by a factor of **1.5** with respect to observations



$\log_{10}(n_H)=8.5$

$n_O/n_H = 10$

$n_{Mg}/n_H = 100$

$n_{Ca}/n_H = 31$

$n_{Fe}/n_H = 0.1$

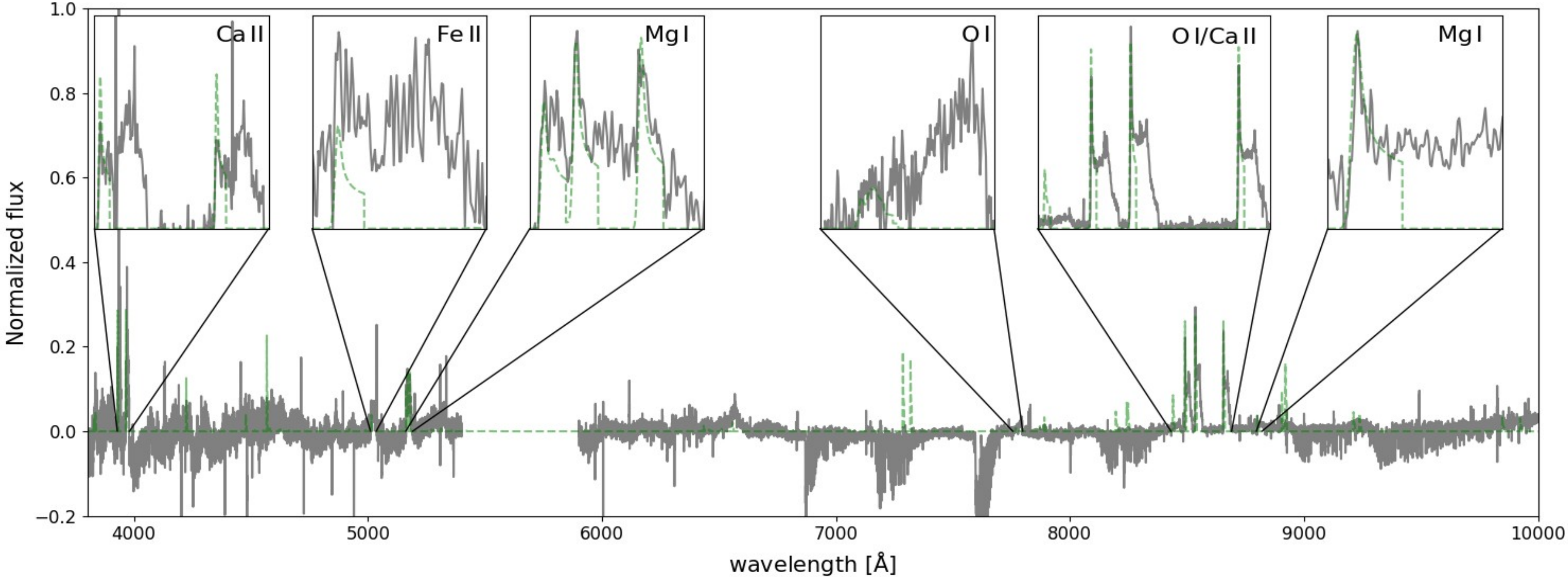
$\rho_{tot} = 10^{-11.7}$ g/cm^3

$n_O/n_{Ca} = 0.31$

$n_{Mg}/n_{Ca} = 3.2$

$n_{Fe}/n_{Ca} = 0.003$

Cloudy Lines ratios differ on average by a factor of 1.5 with respect to observations



$\log_{10}(n_H)=8.5$
$n_O/n_H=10$
$n_{Mg}/n_H=100$
$n_{Ca}/n_H=31$
$n_{Fe}/n_H=0.1$

$\rho_{tot}=10^{-11.7}$ g/cm^3
$n_O/n_{Ca}=0.31$
$n_{Mg}/n_{Ca}=3.2$
$n_{Fe}/n_{Ca}=0.003$

$(n_O/n_{Ca})_{phot}=14.1$
$(n_{Mg}/n_{Ca})_{phot}=4.0$
$(n_{Fe}/n_{Ca})_{phot}=3.1$

Gansicke et al. 2012

Summary

- We have developed a framework to estimate the composition of gaseous discs around WDs using the photoionization code Cloudy.

- Within the capabilities offered by Cloudy, we explore the impact of the disc geometry on the derived chemical compositions.

- No bulk Earth or specific chemical composition is set as a constraint. We explore most of the parameter space of different element abundances combinations.

- For WD J0914+1914, the S/O ratio is in roughly agreement with that obtained in Gansicke et al. 2019. S/O ratio of the best model differ by 1 order of magnitude relative to its photospheric counterpart.

- The best model for SDSS 1228+1040 suggests an hydrogen depleted gas, with a mass density similar to the one obtained for WD J0914+1914 (~10^{-12} g/cm^3)