Constraining the geometry of the nuclear wind in PDS456 using a novel emission model

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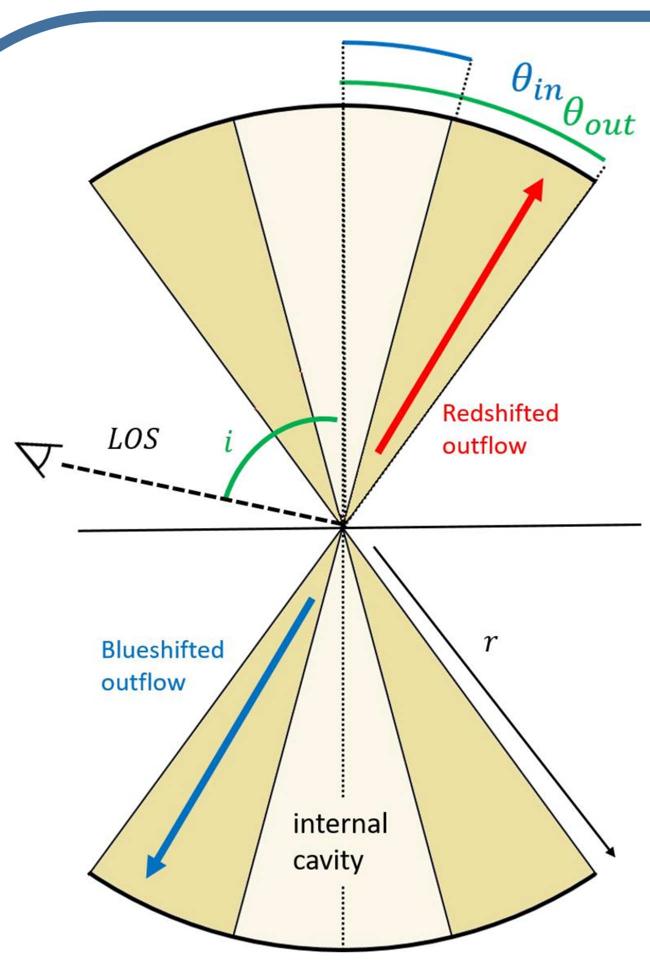
Abstract Outflows from AGNs are a key ingredient in the framework of feedback and coevolution with the host galaxy. In order to constrain the properties and evaluate the impact of the outflows, it is necessary to model their geometry and kinematics from accretion disk up to galaxy-scales.

WINE (WINd Emission) is a Monte Carlo model to simulate geometry and kinematics, and estimate the associated emission line profiles, from the X-ray up to the infrared. We hereby present its features as well as its application to the *Ultra Fast Outflow* (UFO) in the quasar PDS456, a rosetta stone for studying nuclear winds. We also illustrate further developments currently undergoing.

Building the model

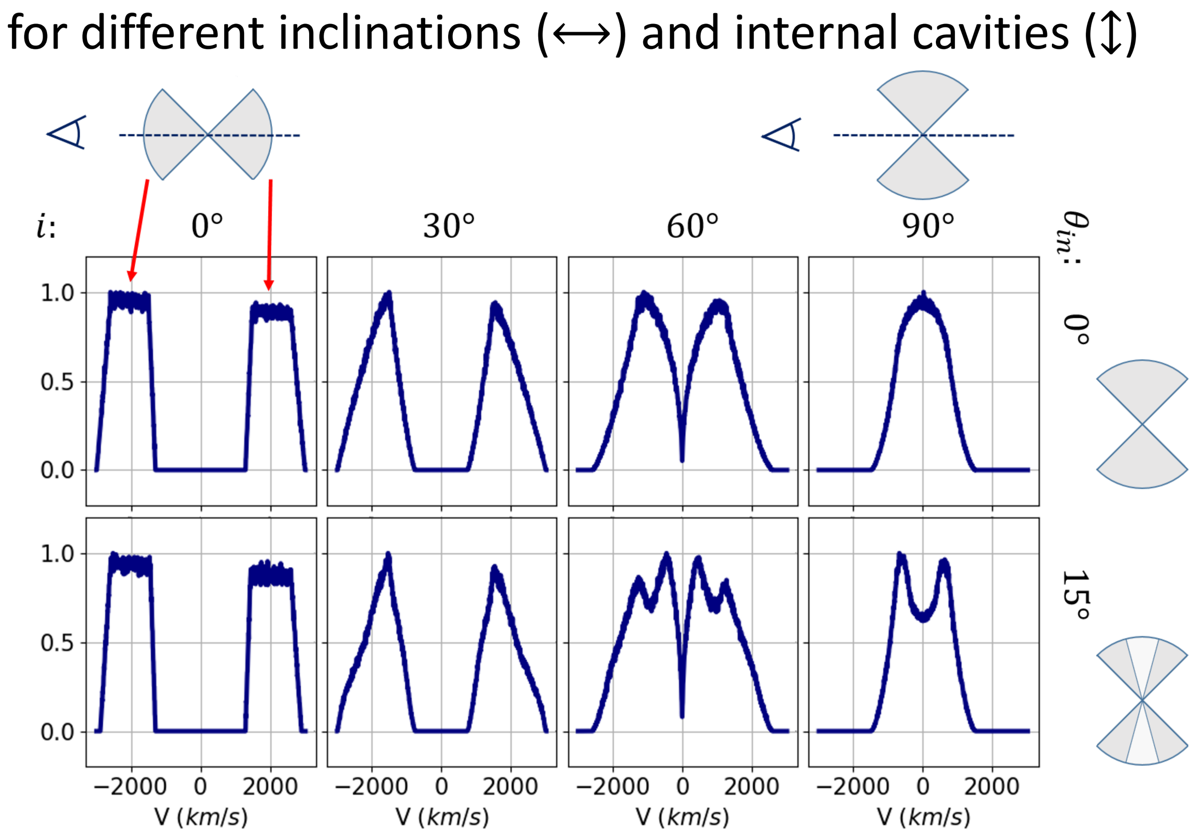


Key features:

- The outflow geometry is biconical. Inclination of the line of sight i, angular opening θ_{out} and internal cavity θ_{in} are free parameters.
- The density profile of the wind is a function of the radius: $n(r) = n_0 \left(\frac{r_0}{r}\right)^{\alpha}$. The exponent α is a free parameter.
- The velocity profile of the wind, $v(r,\theta)$, can be any function of r and θ. This allows to mimic the different wind launching scenarios and to explore momentum- and energy-driven scenarios.

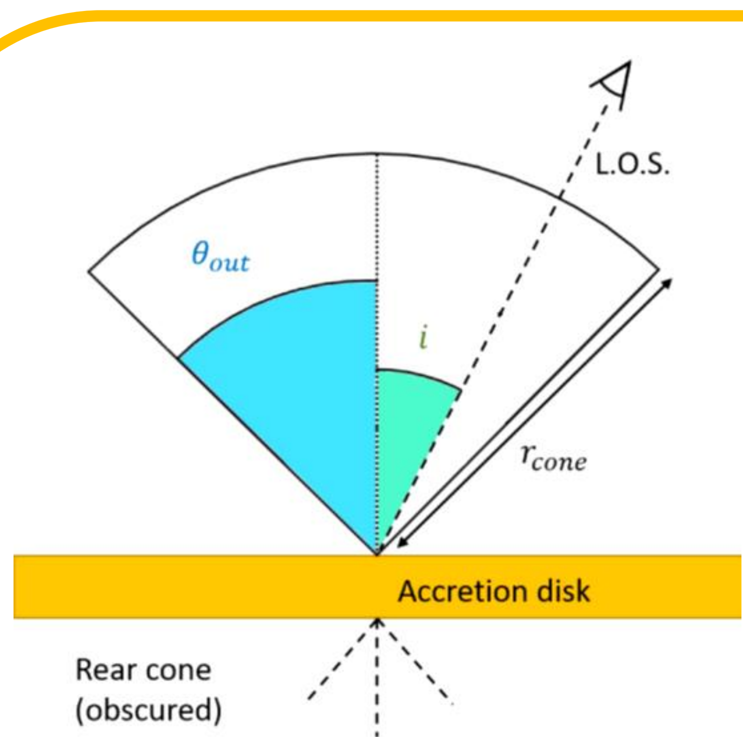
Emission spectrum

for different inclinations (⟷) and internal cavities (↕)



The code can be used for all the outflow stages, from X-ray up to the molecular lines. Several features can be integrated into the code, such as detailed radiative transfer for photoionized gas or turbulent line broadening. For the largest scale outflows, it is possibile to include a galactic disk profile to account for the host galaxy emission.

The UFO in PDS 456



Sketch of the UFO geometry

We consider that *i)* the rear cone is obscured by the accretion disk *ii)* the LOS has to lie inside the wind, since we see both emission and absorption

- The quasar PDS 456 shows a prototypical ultra fast outflow (*UFO*) with $v_{out} \approx 0.25\ c$ and $\dot{E}_{kin} \approx 20\%\ L_{AGN}$, due to Hydrogen-like Iron.
- Using the WINE model, we fit the UFO at $\mathrm{E} \approx 5 - 10\ keV$ with two emission lines for $Fe\ XXVI\ Ly\alpha$ and $Ly\beta$.

Results:

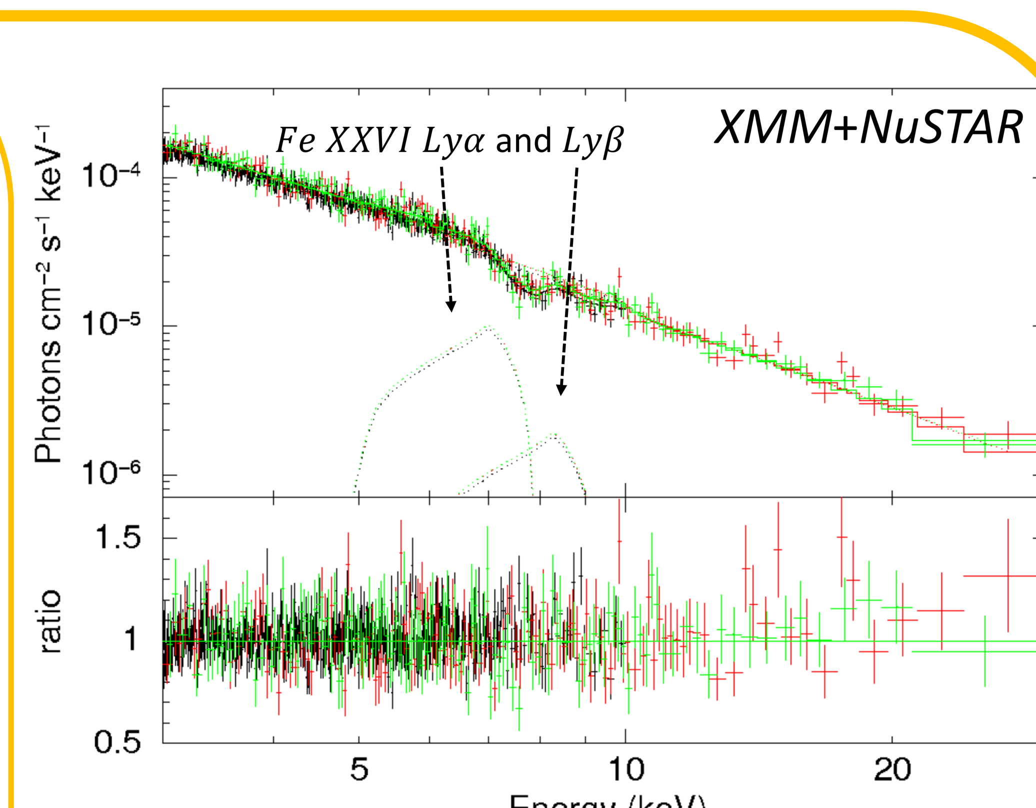
Max wind velocity: 0.28 c

Inclination: 60 deg

Opening angle: 70 deg

Upper limit for the internal cavity: 20 deg

Covering fraction $\sim 70\%$



We fit the spectrum with *xspec*, using:

i) a powerlaw continuum

ii) the WINE model for the emission lines

iii) Gaussian absorption lines and photionization edge for Fe K shell

Further developments

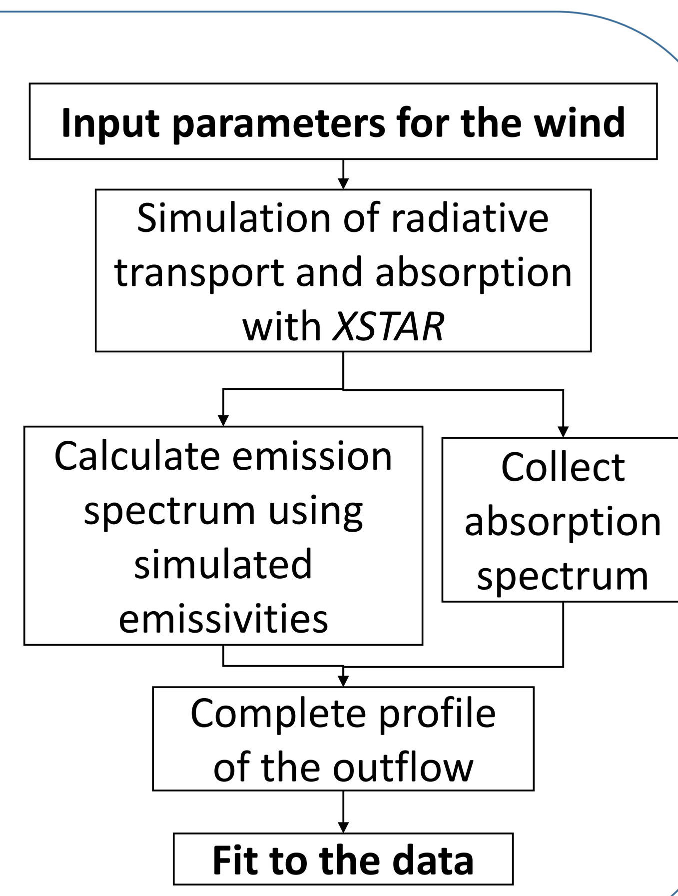
From accretion disk…

Simultaneous modelling of both emission and absorption in X-ray winds

Detailed calculation of radiative transport using the *XSTAR* code. This allows to:

1. Constrain ξ and N_H of the wind
2. Simulate emission profiles using accurate transition rates
3. Include absorption features

The new code will give the possibility to mimic different wind launching mechanism and test their accuracy in fitting the data. **First tests undergoing!**



…to galaxy scales!

Mapping the molecular outflow

To explore the impact of large scale outflows it is necessary to:

1. Separate the emission of the outflow from that of the host galaxy and estimate its obscuration.
2. Parametrize perturbations and small-scale inhomogeneities in the molecular wind.
3. Update outflow geometry according to the galaxy environment.

Already some preliminar result!

Feruglio, Fiore, Carniani *et al.* 2018, A&A in press (arXiv:1804.05566)

The dense molecular gas in the z~6 QSO SDSS J231038+185519 resolved by ALMA