Understanding the distribution and the kinematics of neutral hydrogen from absorption lines

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A variety of profiles

- Upcoming surveys searching for HI absorption (FLASH, SHARP) will detect hundreds of new HI absorption lines.
  - Exploratory work: 66 detections of associated HI absorption out of 248 sources observed with the WSRT.
    - 3 main categories:
      - Narrow lines: FWHM < 100 km/s
      - Medium width lines: 100 km/s < FWHM < 200 km/s
      - Broad lines: FWHM > 200 km/s

[Geréb, Maccagni, et al., 2015]
What’s behind the shape and width of absorption lines:

- In Seyfert galaxies: very different lines can be reproduced by a rotating disk in front of the radio continuum. [Gallimore et al. 1999]

- High resolution observations sometimes show that part of the absorption line is tracing an outflow of gas pushed by the radio jet [Morganti et al. 2005]

⇒ Which lines trace outflows?
⇒ Can we find a systematic way to interpret absorption lines?
Modeling the HI absorber

- Understand the overall distribution of the HI traced by the absorption line
  - **Which lines trace galactic disks? which ones circum-nuclear? which ones outflows?**
    - Ideal solution: trace the HI absorption against the radio jets (VLA, VLBI, EVN)
    - Help of a **kinematical model**:
      - Model the rotating HI disk in front of the radio continuum:

3C 305  Observation  Model

[Jackson et al., 2003]
We fix the parameters of the disk from available information on the galaxy:

- Optical Image: $i$, PA
- Radio continuum image
- Tully Fisher $\rightarrow V_{\text{flat}}$
  - Flat rotation curve

Does the model reproduce the observed line?

- The bulk of the absorption is well reproduced by a rotating disk
- Blue-shifted wing not reproduced by the model
Test the model on a more complex case:

- 3C 293

- Radio jets expanding in the plane of the galaxy
- Central dust lanes misaligned with the optical disk
- The galaxy may have an inner thick disk and outer thin disk aligned edge-on
3C 293

Outer thin disk
+ Inner thick disk
= 

- Reproduce the main features of the line
- Blue-shifted wing not reproduced by the model
Let’s apply the model to a galaxy for which we have less information:

- **4C +52.37**
  - SDSS data give hints on PA, i
  - Radio continuum morphology
  - Flat rotation curve + TF
• The bulk of the absorption is well reproduced by a rotating edge-on disk
• Blue-shifted wing not reproduced by the model
J143521.7+505123

- What about the narrower lines?
- How well do we reproduce them?

[deVries et al., 2009]
The width of the line and some peaks are well reproduced.

Promising for further development
Summary and future developments

• Apply the model to all sources for which we know the radio continuum:
  • Which part of the lines are explained by disks?
  • Are all the narrow and medium lines large scale or circum-nuclear disks?
• can we explain the non-detections?
  • different rotation curve?
  • different inclination of the disk w.r.t. continuum?

• Similar computing experiments

[Pihlstrom, et al. 2003, Curran, et al., 2013] show compact sources should have high HI column density lines. We do not observe this. Why?