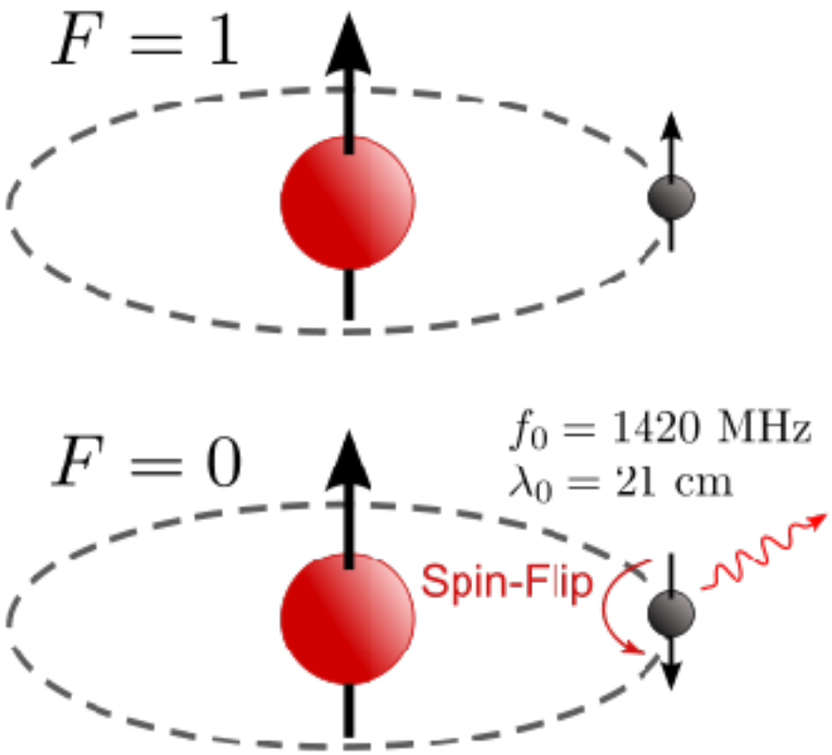
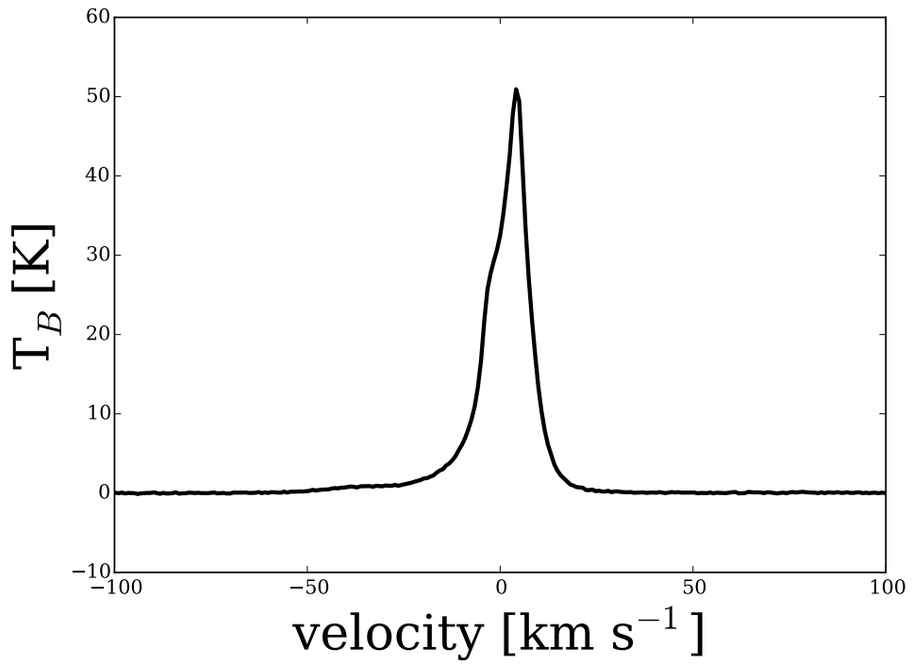
HELGA DÉNES

GAUSSIAN DECOMPOSITION OF SPECTRAL LINES
AND NEUTRAL HYDROGEN IN GALAXIES

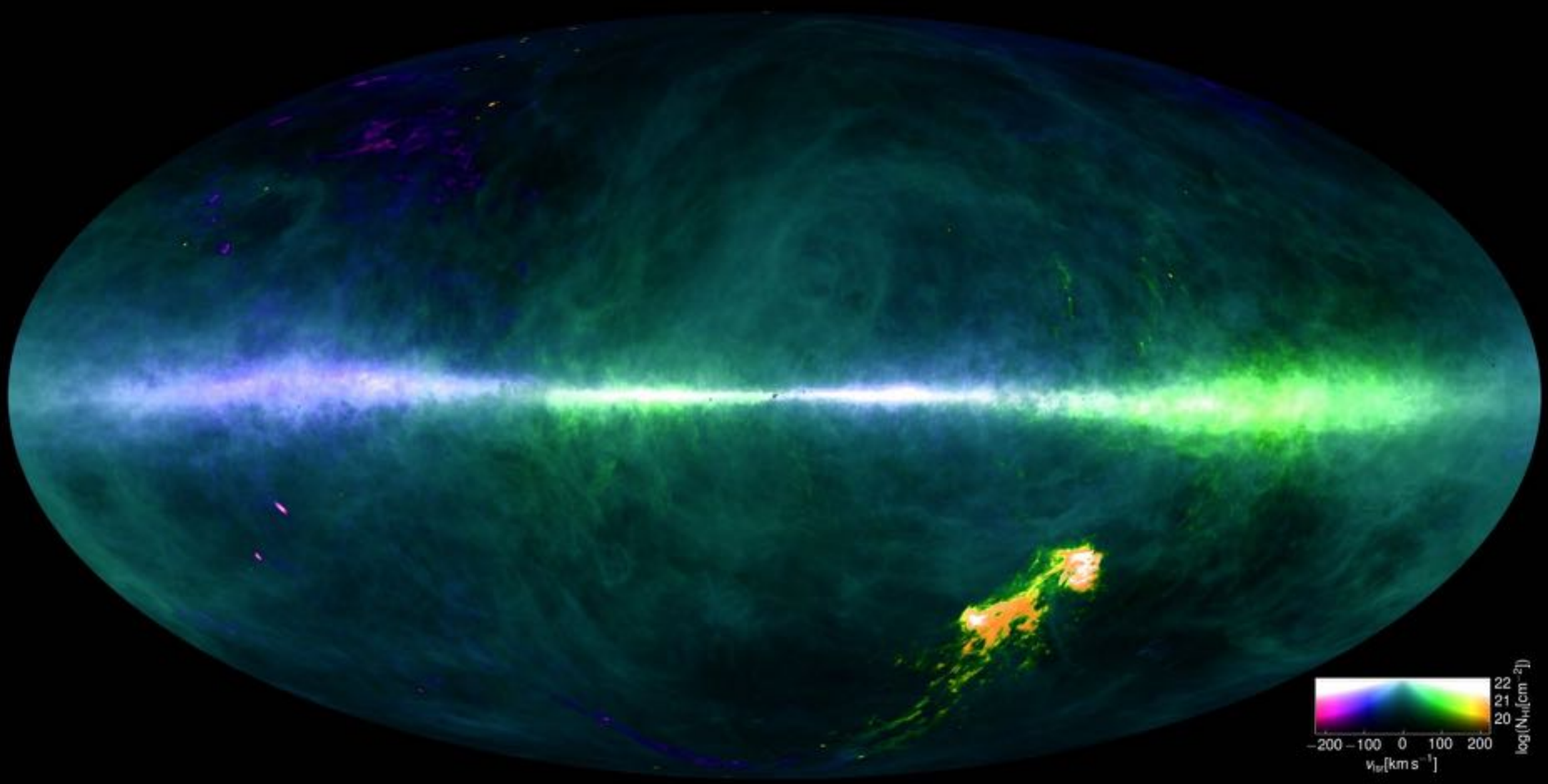
NEUTRAL ATOMIC HYDROGEN (HI) EMISSION





- Hydrogen is the most common element in the Universe
- The neutral atomic hydrogen (HI) emits at 21 cm
- HI is the fuel for potential star formation
- HI is also the lightest atom and very sensitive to disturbances

ATOMIC COLD GAS - HI IN THE MILKY WAY

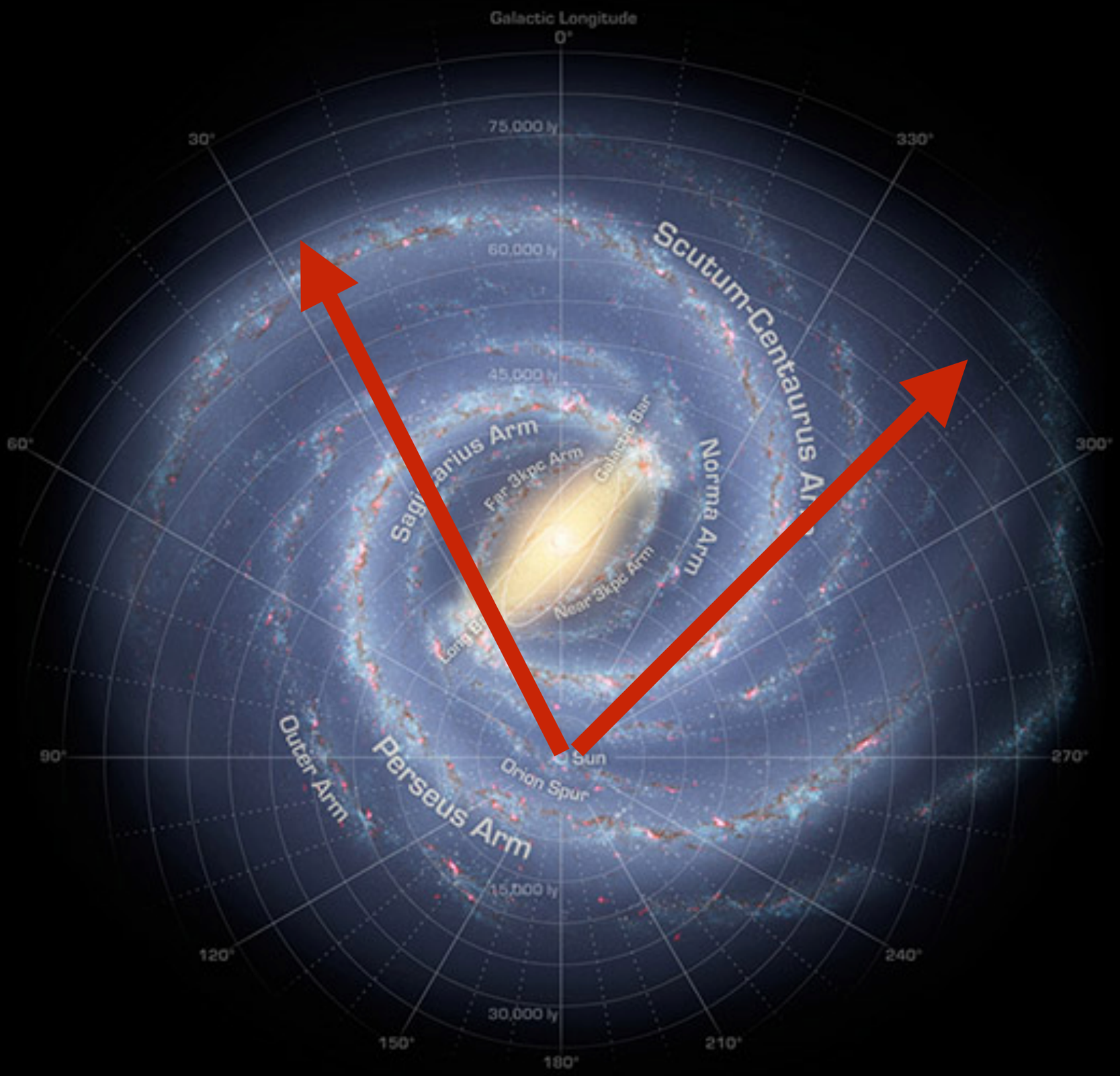


HI4PI, http://www.icrar.org/hi4pi/

THE GALFA HI SURVEY

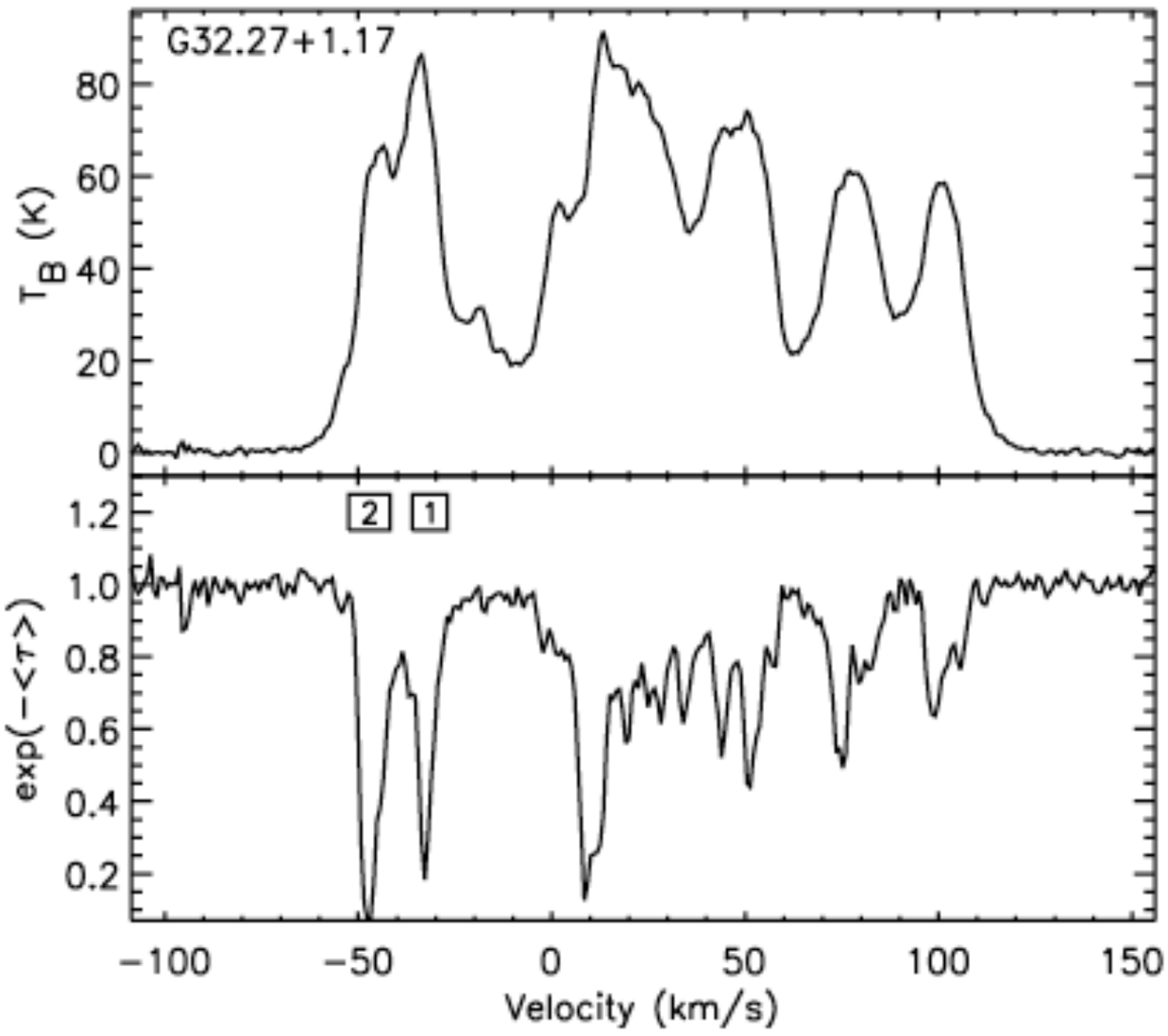
GALFA DR2, Peek et al. in prep, (3’ resolution with Arecibo)

THE MILKY WAY



THE INTERSTELLAR MEDIUM

HI emission



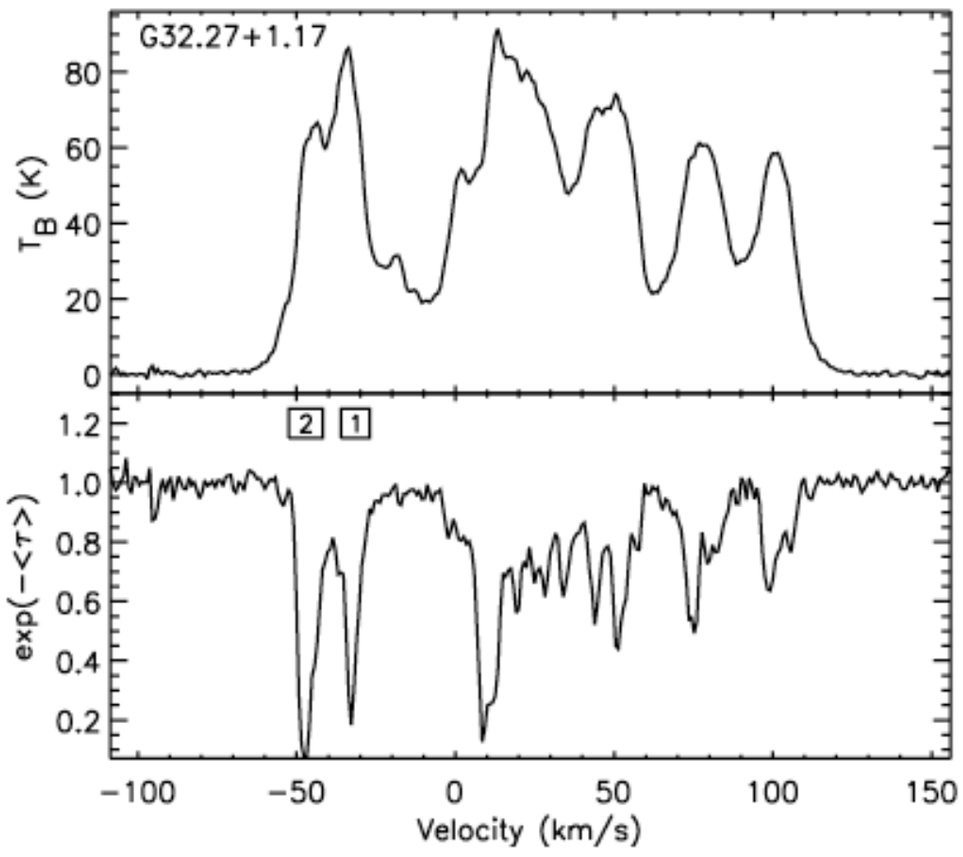
HI absorption

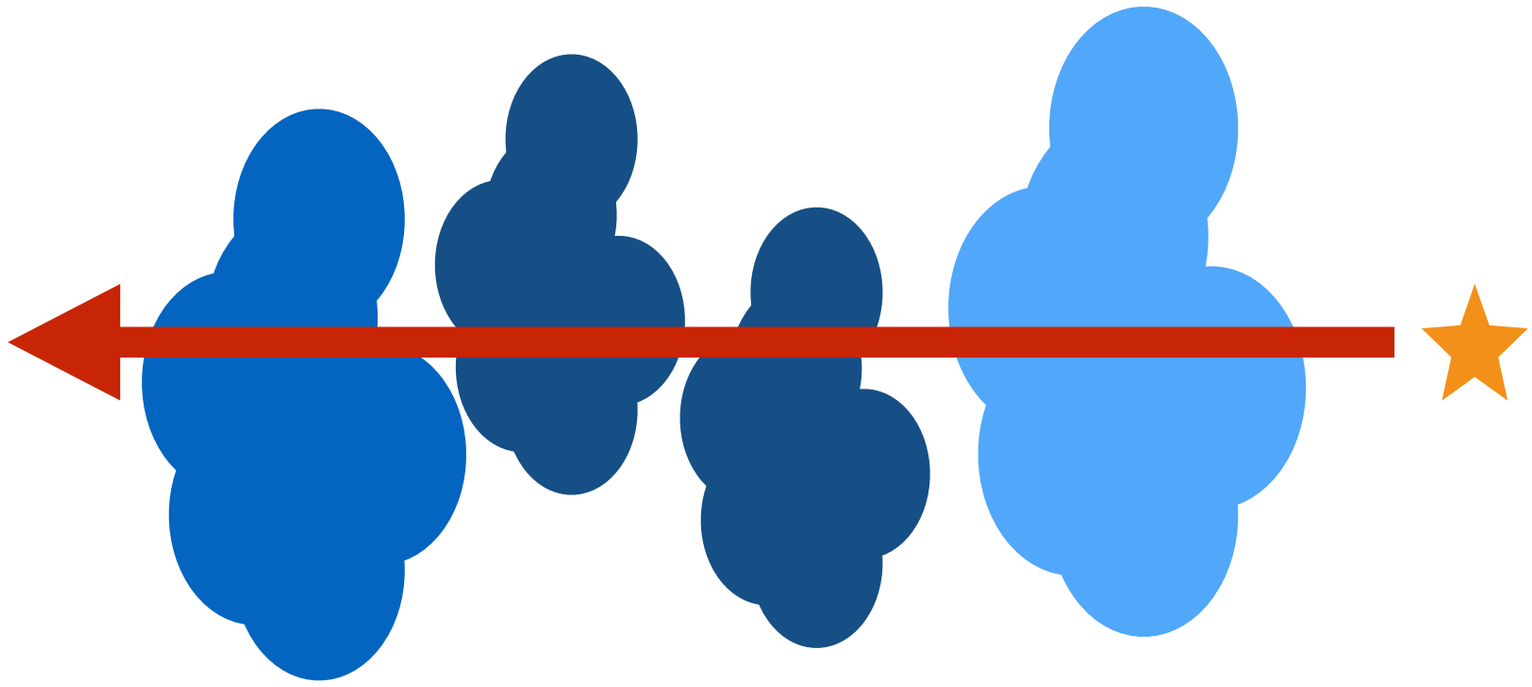
Strasser, Dickey et al. (2007)

1. **WNM** (warm neutral medium) optically thin, 21 cm emission, **T >200K**

2. **CNM** (cold neutral medium) optically thick, 21 cm absorption, **T ~ 50 K**, high volume-gas density, at 10^{20} cm^{-2} HI is saturating and converted into H2

HI ABSORPTION SPECTRA

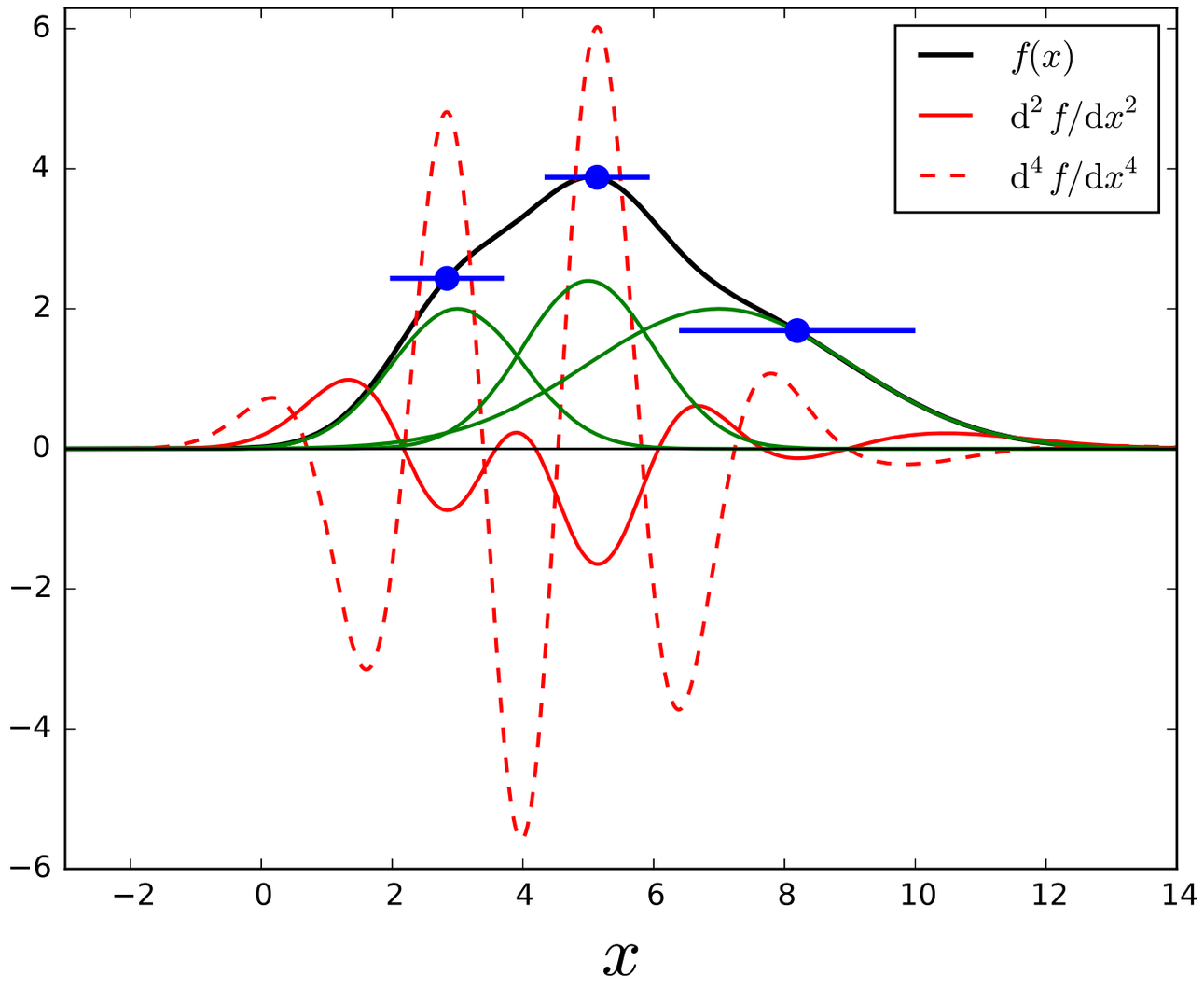




cold HI clouds in absorption

- each cloud corresponds to a Gaussian line
- strongly blended multiple component profiles
- automated decomposition is needed!

GAUSSIAN DECOMPOSITION



Guess criteria:

$$f > 0$$
$$d^2 f/df^2 < 0$$
$$d^3 f/df^3 = 0$$
$$d^4 f/df^4 > 0$$

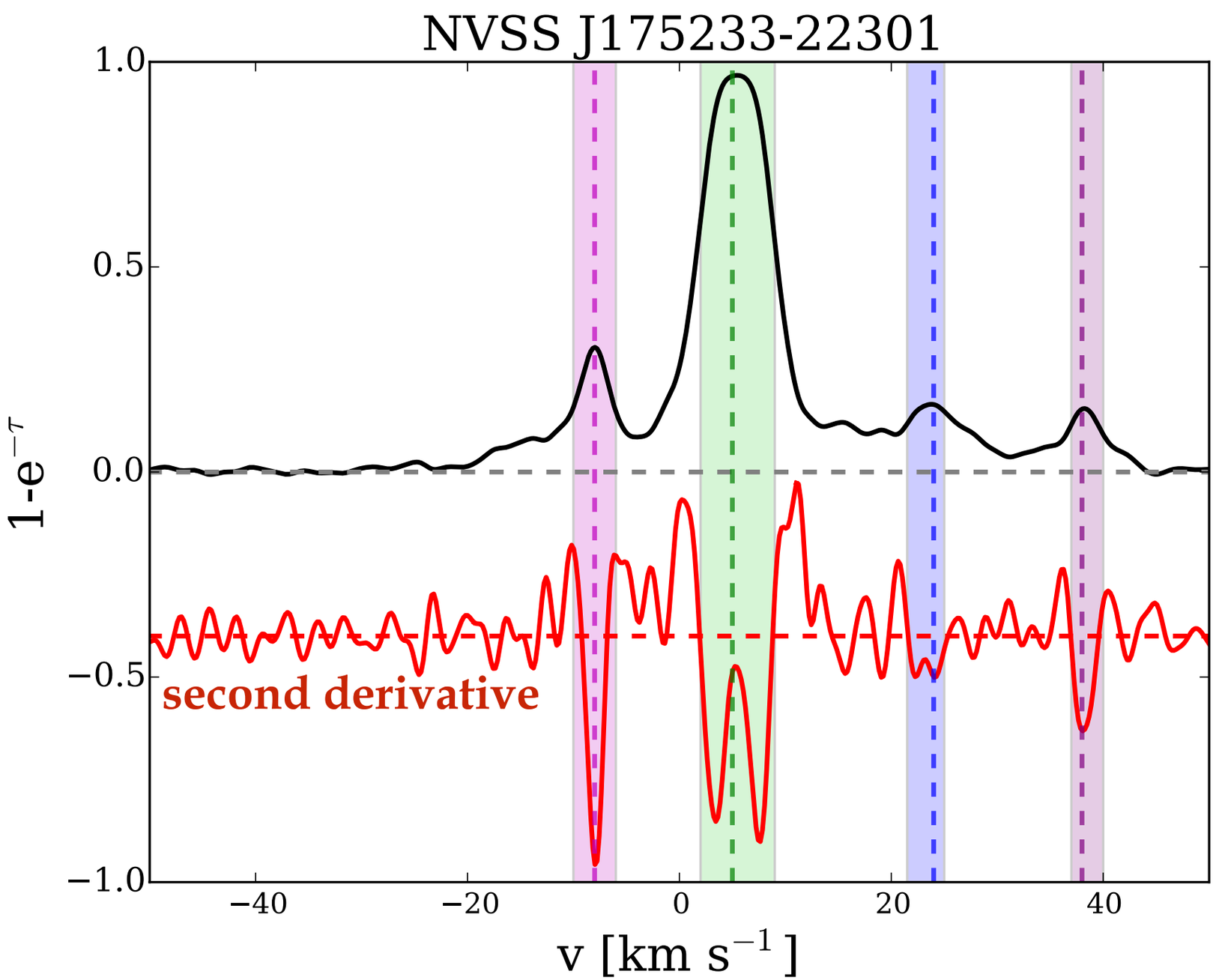
- **Autonomous Gaussian decomposition (GaussPy, Lindner et al. 2015)**
  - based on derivative spectroscopy and machine learning
  - no ‘human’ input needed
  - ideal for large data sets

GAUSSPY

- GaussPy is available on Github: https://github.com/gausspy/gausspy
- can be used to decompose any spectra into Gaussian components
- New, optimised version: https://github.com/mriener/gausspyplus

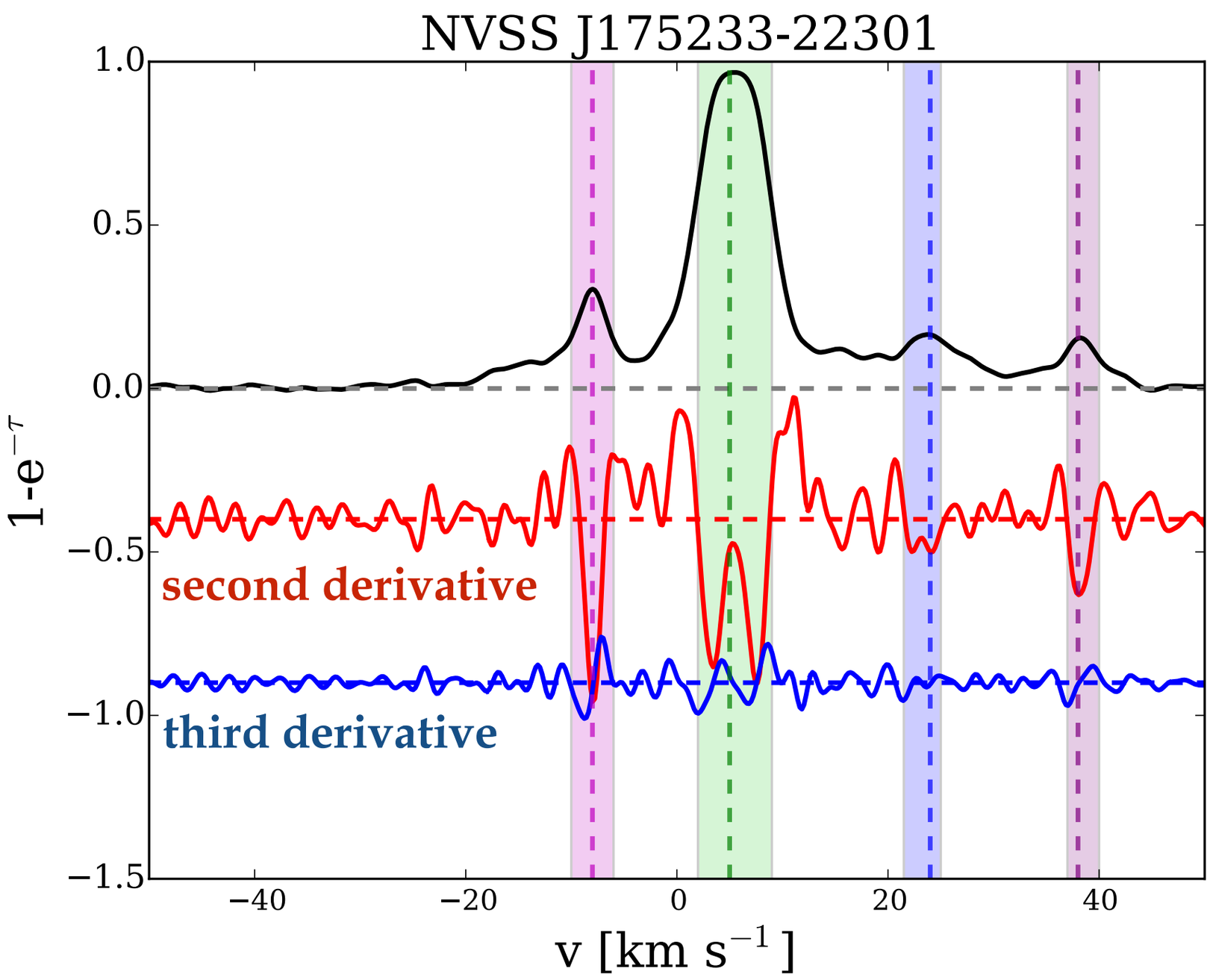
GAUSSIAN DECOMPOSITION

$d^2 f / df^2 < 0$



- **the derivative is used to identify the positions of the Gaussian components**

GAUSSIAN DECOMPOSITION



$$d^2 f / df^2 < 0$$

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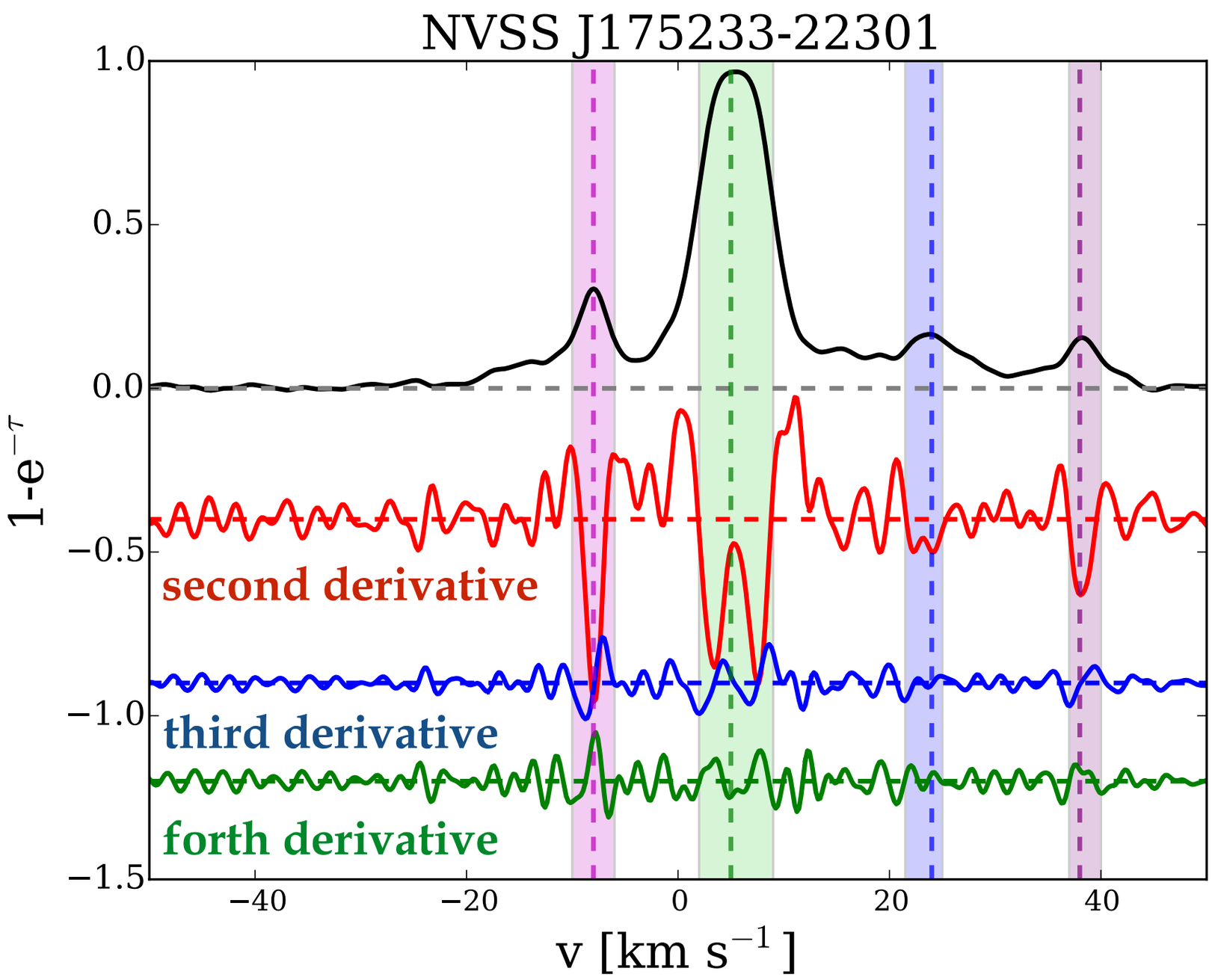

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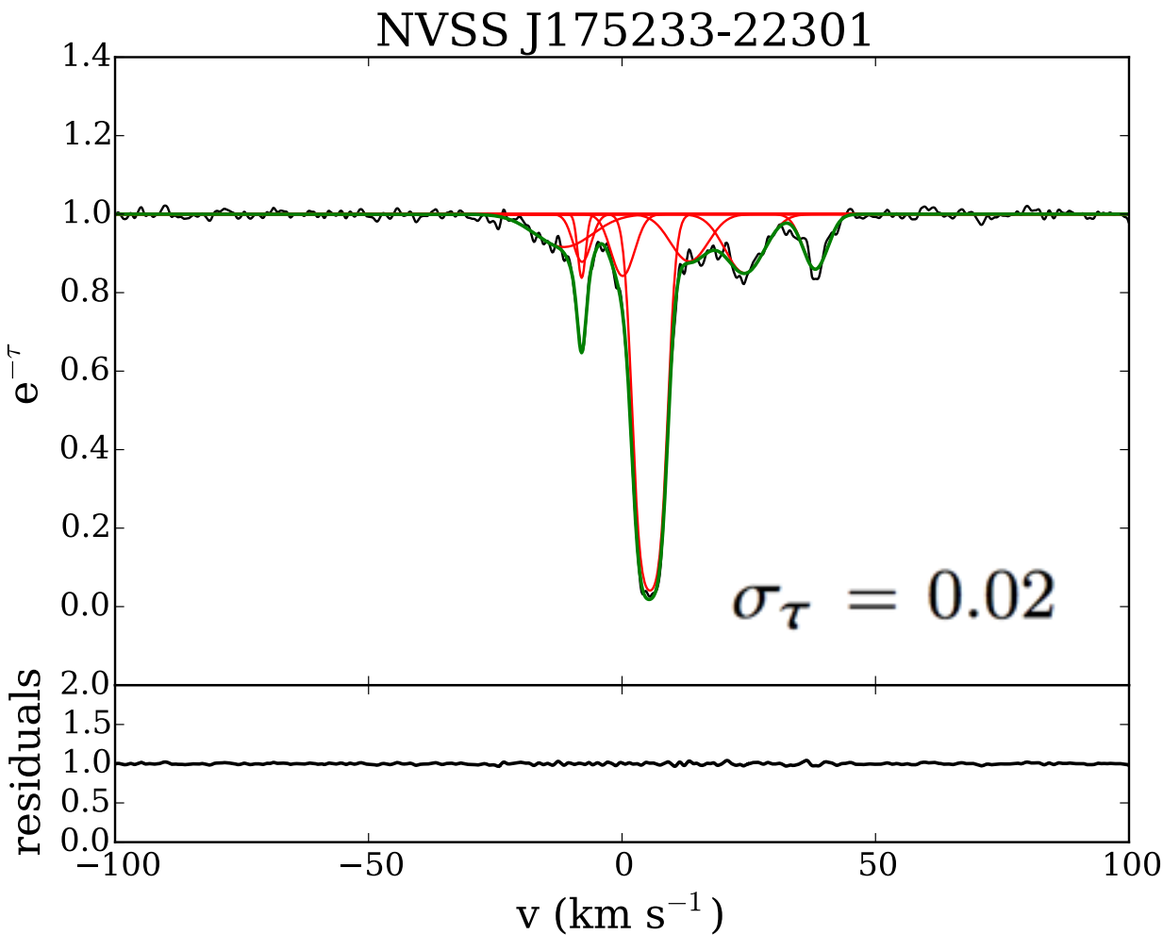
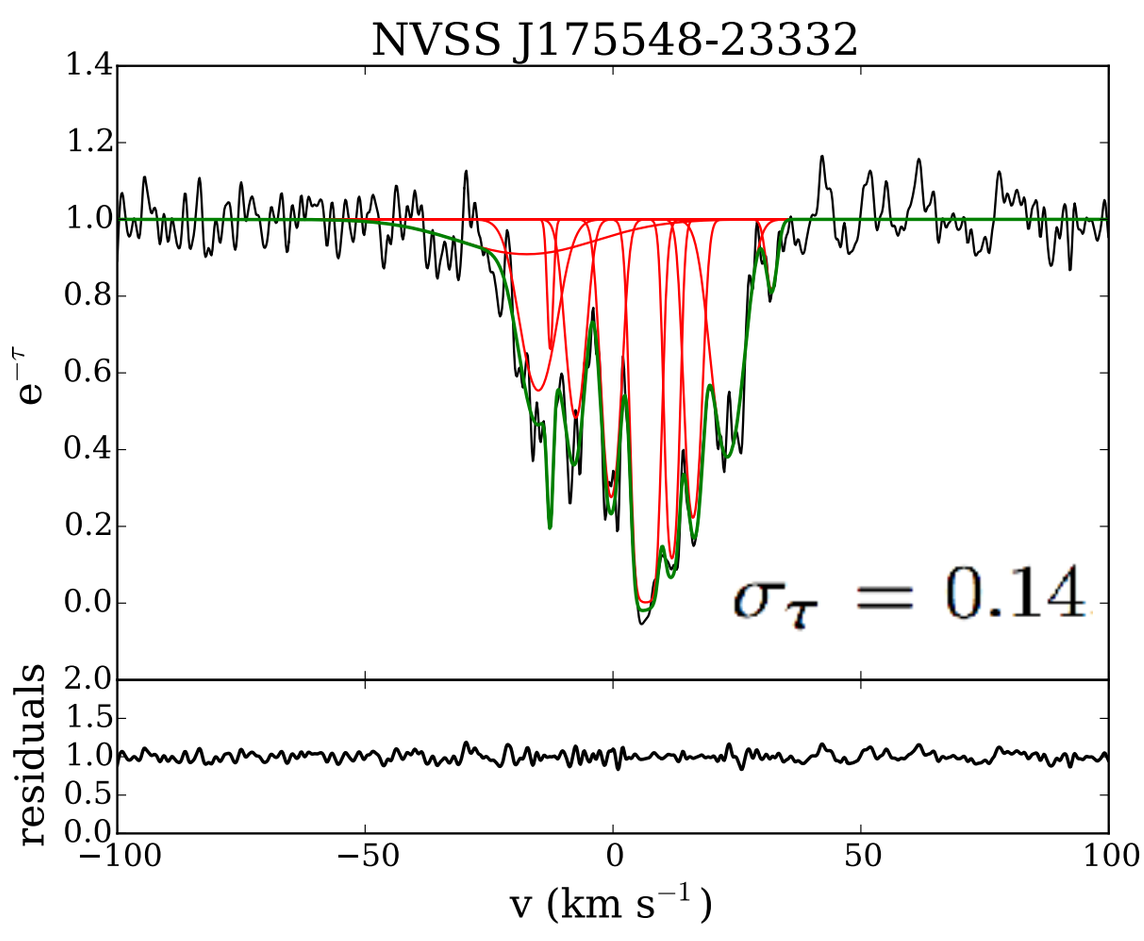
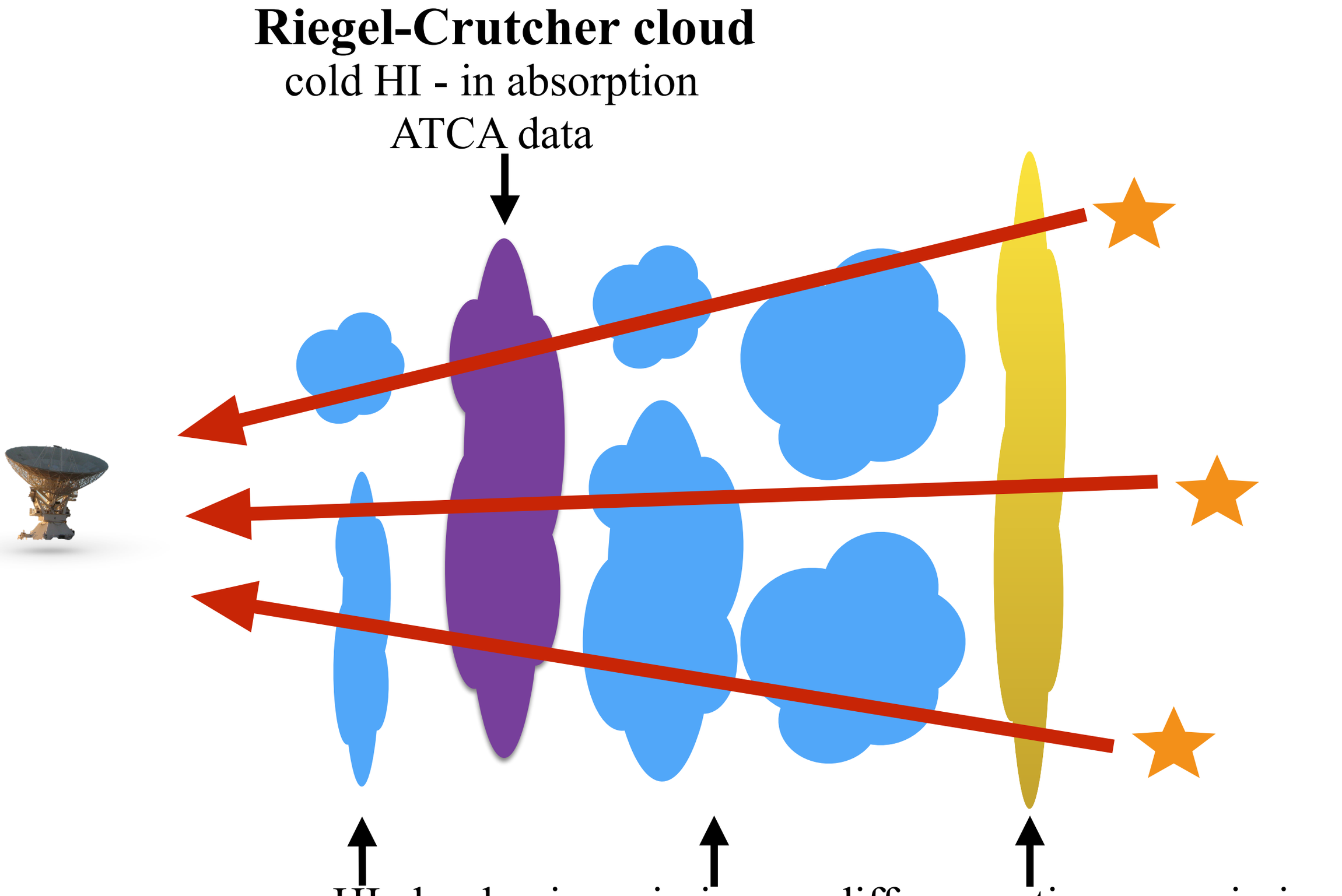
GAUSSIAN DECOMPOSITION





- strongly blended multiple component profiles
- automated Gaussian decomposition with **GaussPy** (Lindner et al. 2015)

4 COMPONENT MODEL



SPIN TEMPERATURES

4 component model:

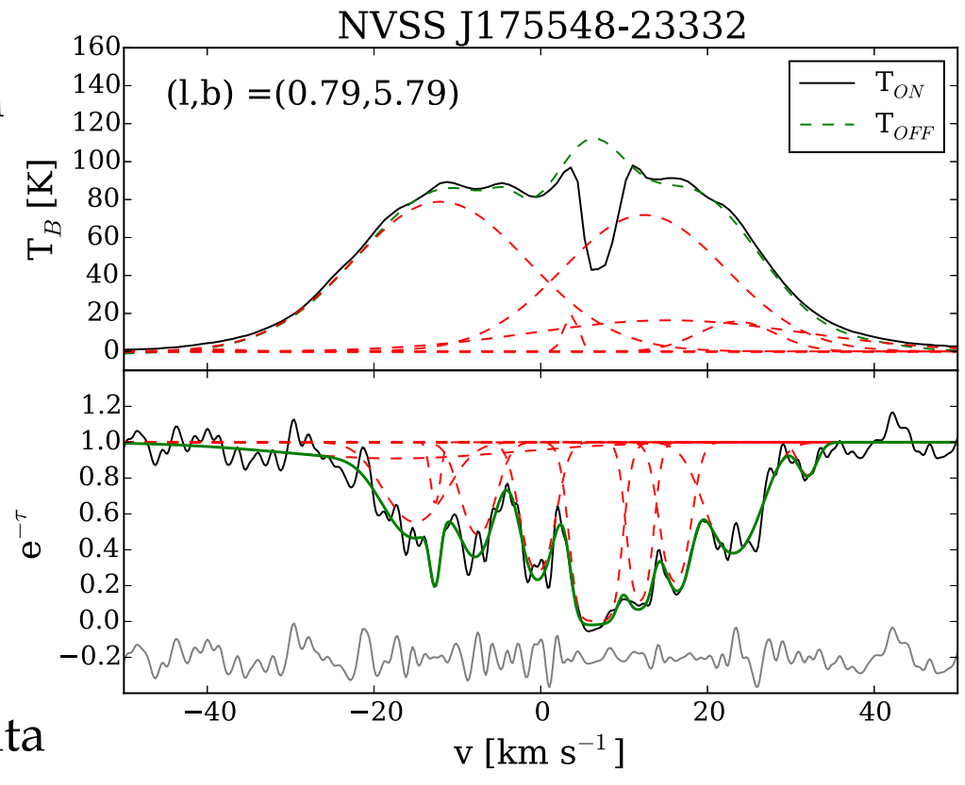
$$T_B = T_{s,fg}(1 - e^{-\tau_{fg}}) + T_{s,HISA}(1 - e^{-\tau_{HISA}})e^{-\tau_{fg}}$$
$$+T_{s,bg}(1 - e^{-\tau_{bg}})e^{-(\tau_{fg}+\tau_{HISA})} + T_c e^{-(\tau_{fg}+\tau_{HISA}+\tau_{bg})}$$

$$T_{ON} - T_{OFF} = (T_{s,HISA} - T_c - pT_{OFF})(1 - e^{-\tau_{HISA}})$$

$$T_s = \frac{T_{ON} - T_{OFF}}{1 - e^{-\tau}} + T_c + pT_{OFF}$$

GASS data

ATCA data

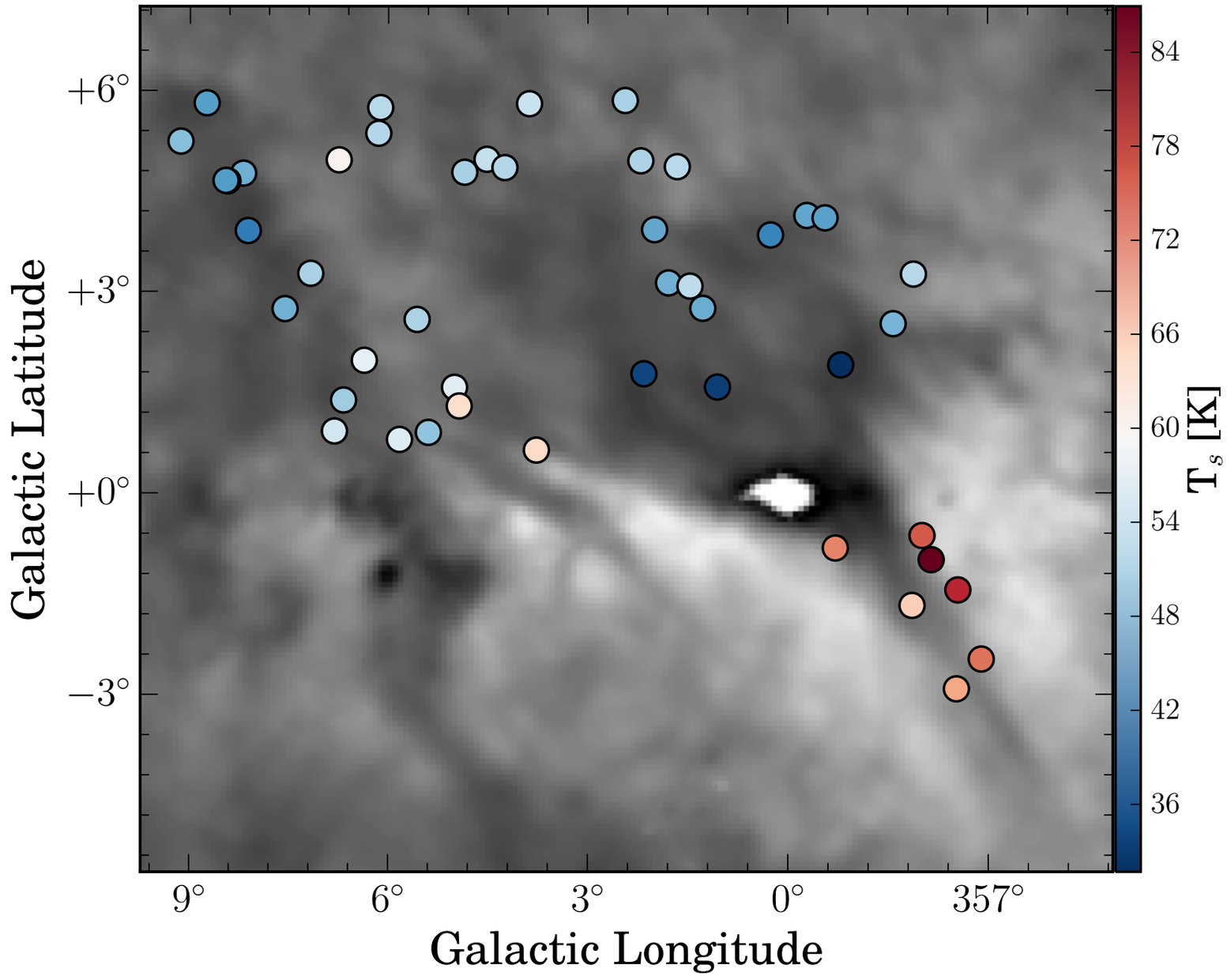


T_{ON}

T_{OFF}

$e^{-\tau}$

SPIN TEMPERATURES



- Ts median 48 K
- Temperature gradient across the cloud
- Molecular cloud formation may start

THANK YOU!