Hands-on reference

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1 Step-by-step setup

Open a terminal and go to the hands-on folder

```
# check where the hard disk is mounted
user@morpheus:~$ df -h
# it should be in /media and called TOSHIBA; let us call the folder [FOLDERHD]; go to that folder
user@morpheus:~$ cd [FOLDERHD]
# go to the astrophysics folder
user@morpheus:[FOLDERHD]$ cd astrophysics_classes/
# go to the folder of the current lecture
user@morpheus:astrophysics$ cd pallottini_synthetic_spectra_from_galaxies_in_cosmological_simulations
```

Update the code with git (optional step)

```
# the folder content is a public github repository, thus it can be updated
#
# check the latest git version on morpheus
user@morpheus:pallottini...simulations$ module avail
# let the last available version be git-[2.X]; load it
user@morpheus:pallottini...simulations$ module load git-[2.X]
# update the repository
user@morpheus:pallottini...simulations$ git pull
```

Setup the code

```
# we have to load the correct modules and compile the cython libraries
#
# load the modules needed by the code (python3 and gcc) with the included bash script
user@morpheus:pallottini...simulations$ source load.sh
# make sure there is a compiled/ subfolder
user@morpheus:pallottini...simulations$ ls | grep compiled
# if it is not present, create it
user@morpheus:pallottini...simulations$ mkdir compiled
# compile the cython routines with the included python script
user@morpheus:pallottini...simulations$ python3 compile_cython.py
```

Run the notebooks

```
# everything should be set at this point, start a notebook kernel
user@morpheus:pallottini...simulations$ jupyter-notebook
# and navigate to the notebook in ipynb/basic_analysis.ipynb
# after that, we will continue with ipynb/spectral_analysis.ipynb
```

2 Exercises

1) **What is the effect of the inclination?** Compute the angular momentum of the system, i.e. $\mathbf{L} = \sum_i m_i \mathbf{x}_i \wedge \mathbf{v}_i$; using the provided rotation subroutines, aling the line of sight (l.o.s.) with i) $\hat{n}_{\rm L} = \mathbf{L}/|\mathbf{L}|$ and ii) a versor along the plane perpendicular to $\hat{n}_{\rm L}$; when rotating of $\mathbf{x}$, check that you are consistenly transforming $\mathbf{v}$, that is inportant in the calculation of the l.o.s. velocity. What are the differences in the imaging and the spectroscopy of [CII]?

2) **Which are the characteristics of the gas responsible for the [CII] emission?** Produce and take a look at the phase-diagram in the Z-n and T-n plane by mass weighting the PDF with $L_{\rm [CII]}$. Are there Z, n, and T spots where the emission peaks? What about the dispersion around the peaks? What are the Z-n-T ranges of the gas that account for most of the emission?

3) **How would the [CII] emission look like in a typical observation with ALMA?** Consider that typical noise for an ALMA observation of the object of interest can be approximated as $N = 74.8\,\mu{\rm Jy}(t/1{\rm hr})^{-0.5}\,(\sigma_{\rm beam}/0.5{\rm a.s.})^2$, where t is the observing time and $\sigma_{\rm beam}$ the linear size of the beam (in arcseconds, can be converted in kpc by using astropy). Beam smearing effect can be mimiked by convolving the image with a 2D gaussian filter with size $\sigma_{\rm beam}$; for the spectra, it can be approximated as a random gaussian distribution with amplitude N and zero mean; what is the required beam size to image the satellite of Althæa? What is the observing time needed to have a good spectral determination of the galaxy? What is the setup needed to exctract the spectrum of the satellite?