dark_compact_V1_LR_fix

August 13, 2020

[1]:
```
%load_ext autoreload
%autoreload 2

%config IPCompleter.greedy=True
```

[2]:
```
import matplotlib.pyplot as plt
import numpy as np
import h5py
from astropy import units
from pathlib import Path
import os
import time

import snapshot_obj
import dataset_compute
import curve_fit

import importlib
```

[3]:
```
importlib.reload(snapshot_obj)
importlib.reload(dataset_compute)
importlib.reload(curve_fit)
```

[3]:
```
<module 'curve_fit' from
'/home/kasper/Curvaton_Simulations/analysis/curve_fit.py'>
```

1 Massive compact non-luminous halos

Here, we inspect the properties of the clump of subhalos in the ΛCDM simulation with $v_{\rm max} \sim v_{\rm 1kpc} > 30 \mathrm{km/s}$.

1.1 Construct selection arrays

Read $v_{\rm max}$ and $v_{\rm 1kpc}$ and construct mask arrays for the peculiar dark subhalos, and for all dark subhalos in the same mass range.

[4]:
```
sim_id = "V1_LR_fix"
snap = snapshot_obj.Snapshot(sim_id, 127)
max_point = snap.get_subhalos("Max_Vcirc", "Extended")
vmax = max_point[:,0] * units.cm.to(units.km)
v1kpc = snap.get_subhalos("V1kpc", "Extended") * units.cm.to(units.km)
```

[13]:
```
masks_sat, mask_isol = dataset_compute.split_satellites_by_group_number(
    snap, (1,0), (2,0))
mask_dark = dataset_compute.split_luminous(snap)[1]
mask_pecul = np.logical_and(vmax > 35, np.abs(vmax-v1kpc)/vmax < 0.15)
mask_pecul = np.logical_and.reduce([mask_isol, mask_dark, mask_pecul])
mask_ref = np.logical_and(vmax > 30, vmax < 50)
mask_ref = np.logical_and.reduce([mask_isol, mask_dark, mask_ref])
```

Inspect the constituents of the peculiar subhalos:

[14]:
```
masstype = snap.get_subhalos("MassType") * units.g.to(units.Msun)
for m_arr in masstype[mask_pecul]:
    print(["{:.2E}".format(m) for m in m_arr])
```

```
['4.02E+08', '7.58E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['2.74E+08', '7.70E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['3.71E+08', '5.78E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['2.24E+08', '5.17E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['1.38E+08', '4.78E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['2.27E+08', '4.39E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['2.24E+08', '3.65E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['2.27E+08', '2.25E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
['1.00E+08', '2.96E+09', '0.00E+00', '0.00E+00', '0.00E+00', '0.00E+00']
```

1.2 Plot the rotation curves

Let us first see how many there are of these peculiar halos, and compare that to the number of all halos in the mass range:

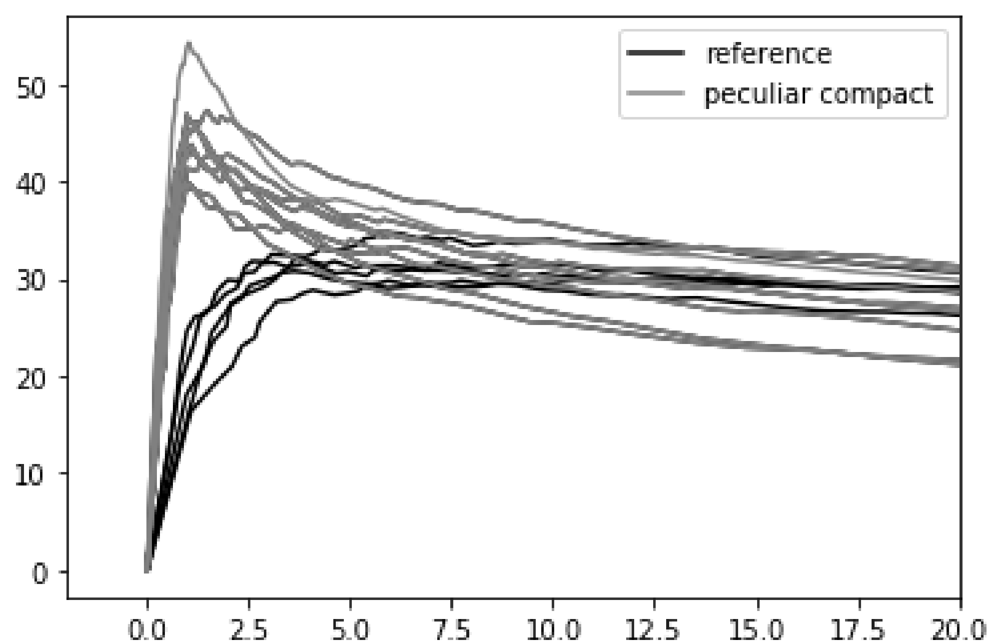
[15]:
```
print(np.sum(mask_pecul))
print(np.sum(mask_ref))
print(np.sum(np.logical_and(mask_pecul, mask_ref)))
```

```
9
13
8
```

We see that the rotation curves of the subhalos in the given mass range divide into two classes: very compact ones, which constitute the clump in the V1kpc plots, and more regular looking ones.

[16]:
```
rot_curves = snap.get_subhalos('Vcirc', group='Extended/RotationCurve/All')
sub_offset = snap.get_subhalos('SubOffset', group='Extended/RotationCurve/All')
```

```
fig, axes = plt.subplots()
axes.set_xlim(-2, 20)

idxs = np.arange(mask_pecul.size)[mask_ref]
for i,idx in enumerate(idxs):
    v_circ = rot_curves[sub_offset[idx]:sub_offset[idx+1],0] * units.cm.
↪to(units.km)
    radii = rot_curves[sub_offset[idx]:sub_offset[idx+1],1] * units.cm.to(units.
↪kpc)
    if i==0:
        axes.plot(radii, v_circ, c='black', label="reference")
    else:
        axes.plot(radii, v_circ, c='black')

idxs = np.arange(mask_pecul.size)[mask_pecul]
for i,idx in enumerate(idxs):
    v_circ = rot_curves[sub_offset[idx]:sub_offset[idx+1],0] * units.cm.
↪to(units.km)
    radii = rot_curves[sub_offset[idx]:sub_offset[idx+1],1] * units.cm.to(units.
↪kpc)
    if i==0:
        axes.plot(radii, v_circ, c='gray', label="peculiar compact")
    else:
        axes.plot(radii, v_circ, c='gray')

plt.legend()
plt.savefig("rotation_curves_peculiar_{}.png".format(sim_id), dpi=200)
```



Let us see, what is the constitution of the mass near the centre. We calculate the rotation curves with bins of three particles:

[17]:
```
pts = {'all': None, 'gas': [0], 'dm': [1]}
v_circ = {}
radii = {}

for key, pt in pts.items():
    if pt is None:
        v, r = dataset_compute.compute_rotation_curves(snap, n_soft=3)
    else:
        v, r = dataset_compute.compute_rotation_curves(snap, n_soft=3,␣
 ↪part_type=pt)

    v_circ[key] = v[mask_pecul] * units.cm.to(units.km)
    radii[key] = r[mask_pecul] * units.cm.to(units.kpc)
```

```
Computing subhalo rotation curves for V1_LR_fix…
Done.
Computing subhalo rotation curves for V1_LR_fix…
Done.
Computing subhalo rotation curves for V1_LR_fix…
Done.
```

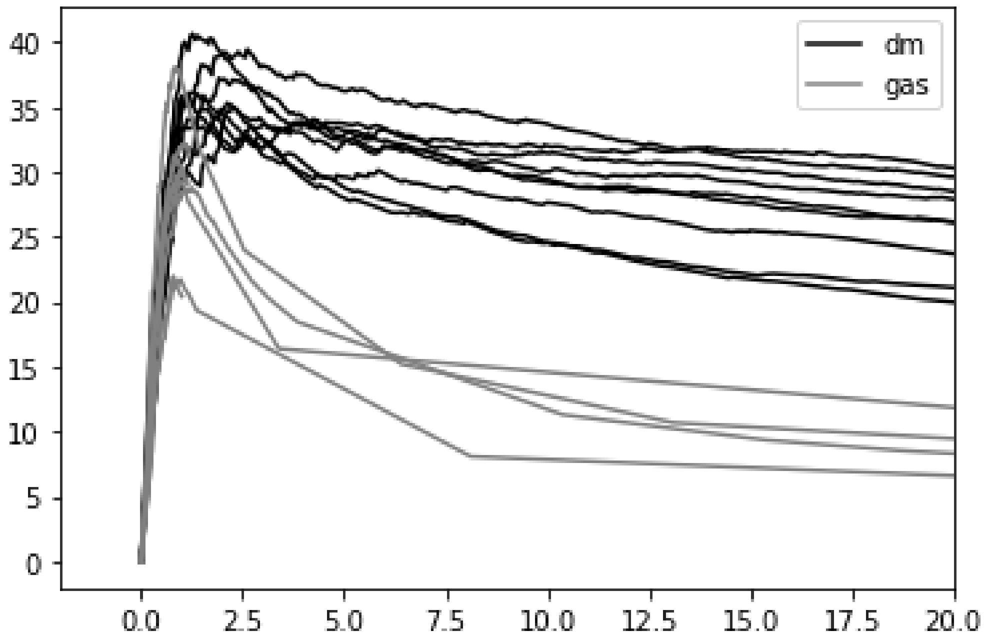
[18]:
```
for pt in pts.keys():
    print("Particle type: {}\n".format(pt) + \
          "Number of particles in the peculiar subhalos within radii\n" +\
          "   1kpc   2kpc")
    for r in radii[pt]:
        print("  {:3d}    {:3d}".format(np.sum(r < 1), np.sum(r < 2)))
    print('')
```

```
Particle type: all
Number of particles in the peculiar subhalos within radii
   1kpc   2kpc
   55      98
   63      85
   88     109
   54      77
   36      50
   58      77
   61      75
   62      78
   34      47
```

```
Particle type: gas
Number of particles in the peculiar subhalos within radii
   1kpc   2kpc
   42     66
   54     63
   72     77
   45     48
   25     28
   48     52
   49     51
   48     52
   22     23

Particle type: dm
Number of particles in the peculiar subhalos within radii
   1kpc   2kpc
   14     33
   10     23
   17     33
   10     30
   11     22
   11     26
   13     25
   14     26
   12     24
```

[19]:
```python
fig, axes = plt.subplots()

axes.set_xlim(-2, 20)

for i, (v, r) in enumerate(zip(v_circ['dm'], radii['dm'])):
    if i==0:
        axes.plot(r, v, c='black', label="dm")
    else:
        axes.plot(r, v, c='black')

for i, (v, r) in enumerate(zip(v_circ['gas'], radii['gas'])):
    if i==0:
        axes.plot(r, v, c='grey', label="gas")
    else:
        axes.plot(r, v, c='grey')

plt.legend()
```

[19]: <matplotlib.legend.Legend at 0x7f3a33e3fcd0>



1.3 Further inspection

Let us see, how far from the LG centre the peculiar subhalos are located:

[20]:
```
LG = dataset_compute.compute_LG_centre(snap, (1,0), (2,0))
dist_to_lg = dataset_compute.distance_to_point(snap, LG) * units.cm.to(units.
 ↪kpc)
print(dist_to_lg[mask_pecul])
```

```
[4185.52818012 2224.18307205 3523.25947974 4366.95337038 2716.80090491
 2055.48169961 6386.29645828 1640.93474286 4249.612726  ]
```