

February 21, 2018

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## ECO, Resolve A, and Resolve B Catalogues

### 1 Mock Catalogues

We construct a set of mock catalogues from a cosmological  $180 h^{-1}\text{Mpc}$  N-body cube simulation that traces the evolution of dark matter in the Universe. The dark matter (DM) halos are found by applying a Friends-of-Friends algorithm [Davis et al., 1985, FoF;] to link together particles separated by a specified linking length equal to 0.2 times the mean inter-particle separation of the DM particles. The total mass of the dark matter halo is the sum of all the contributing DM particles. The suite assumes *Planck 2015* [Collaboration, 2016] cosmology and uses the Warren et al. [2006] halo mass function.  $\Omega_{m,0} = 0.307$ ,  $\Omega_{b,0} = 0.0486$ ,  $\Omega_{\Lambda,0} = 0.6918$ ,  $h = H_0 / (100 \text{ km s}^{-1} \text{ Mpc}^{-1}) = 0.7$ , mass function.

We use an HOD [Berlind & Weinberg, 2002] model to populate the DM halos with galaxies. We differentiate between central and satellite galaxies in the halo, each following different probability distributions. For each set of mock catalogues, the numbers of central and satellite galaxies as a function of halo mass were chosen to reproduce the number density,  $n_{gal}$  of the ECO survey. The central galaxy is located at the minimum of the potential well of the halo, and is assigned the mean velocity of the DM halo. Satellite galaxies are assigned the positions and velocities of randomly chosen DM particles bound to the host halo.

#### 1.1 Conditional Luminosity Function

To assign luminosities to the mock galaxies, we adopt the formalism of the *conditional luminosity function*  $\Phi(L|M)$  [CLF; Yang et al., 2003, Van Den Bosch et al., 2003] and [C09; Cacciato et al., 2009], which gives the number of galaxies with luminosities in the range of  $L \pm dL/2$  that are member of a halo of mass  $M$ . This allows us to create a link between the distribution of DM halos and that of the residing galaxies, while also differentiating between central and satellite galaxies (c.f. Eq. 32-39 in C09).

For the purpose of the project, we want to mimic the luminosity function of ECO. We assign real ECO  $r$ -band absolute magnitudes taken from the ECO survey. We make use of the ranking of luminosities from the CLF method and use it to determine the order, in which galaxies get assigned absolute magnitudes. We determine the ratio of the number of mock galaxies to the number of real galaxies, i.e.  $f_{mr}$ . We assign the most luminous ECO  $r$ -band absolute magnitude to the first  $f_{mr}$  most luminous mock galaxies, according to the CLF. We keep assigning the next most luminous SDSS  $r$ -band absolute magnitude to the next set of  $f_{mr}$  most luminous mock galaxies, until all mock galaxies have been assigned an SDSS  $r$ -band magnitude. This method will then preserve the  $r$ -band luminosity function in the data.

#### 1.2 Other galaxy properties

We want to assign other properties, other than  $r$ -band absolute magnitudes, to the mock galaxies. For each mock galaxy, we find the galaxy in the data that has the closest  $r$ -band absolute

magnitude to that of the mock galaxy. Then we assign all the associated galaxy properties of the *real* galaxy to the mock galaxy. In that way, we are assigning real galaxy property values to the mock galaxies.

### 1.3 Geometrical and Redshift Cuts

As the final step, we construct volume-limited galaxy galaxy redshift survey catalogues from the simulation box. Depending on the survey geometry, we place a virtual observer at different positions in the box, in order to maximize the total number of mock catalogues out from the box. We first place a virtual observer at the starting position in the box, and define right ascension (RA) and declination (Dec) for each galaxy with respect to the virtual observer. Then, for every mock galaxy, we compute the angular coordinates and redshift, including the effect due to the line-of-sight peculiar velocity of the galaxy, i.e. *redshift-space distortions*. After carving out the geometry of the survey and only selecting those mock galaxies that fall within the survey geometrical limits, we place the virtual observer to the next location, and repeat the same procedure. The final result is a set of volume-limited galaxy galaxies in redshift-space, with the exact same geometry as ECO, Resolve A, or Resolve B. We construct set of 59, 104, and 8 volume-limited mock galaxy catalogues for Resolve A, Resolve B, and ECO surveys, respectively. The resulting mock catalogues can be downloaded from Section 3.

### 1.4 Group-Finding algorithm and Group Catalogue

Additionally, we want to assign galaxies to galaxy groups. We use the [Berlind et al. \[2006\]](#) FoF algorithm with a set of linking lengths  $l_{\perp} = 0.07$  and  $l_{\parallel} = 1.1$ , in units of the mean inter-galaxy separation. For each group, we calculate the properties shown in the *README.md* file attached.

## 2 Survey of Volumes

The volumes used to create the catalogues are the following (in units of  $h^{-3}\text{Mpc}^3$ ):

Survey	Number of Mocks	Volume [ $h^{-3}\text{Mpc}^3$ ]
Resolve A	59	20,957.7789388
Resolve B	104	15,908.063125
ECO	8	192,294.221932

## 3 Download Mock Catalogues

You can download the mock catalogues for the 3 different survey at:

- ECO: [Link](#)
- Resolve A: [Link](#)
- Resolve B: [Link](#)
- Mass Function: [Link](#)

## 4 README

# ECO and RESOLVE MOCK CATALOGUES

Repository for the mock catalogues - Normal Version

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**Date:** July 24th, 2017

This README file describes the mock galaxy catalogues for the different survey geometries, i.e. for *ECO*, *Resolve A*, and *Resolve B*. The table and text were produced using markdown language.

This is a summary of the values used to create these mock catalogues: These catalogues are taking into account the extra buffer along the *cz* direction in redshift space.

Survey	RA (Deg)	RA Range	DEC (Deg)	DEC Range	<i>z</i> <sub>min</sub>	<i>z</i> <sub>max</sub>	V <sub>min</sub> (km/s)	V <sub>max</sub> (km/s)	Dist (Mpc)
A	(131.25, 236.25)	105.0	(0, +5)	5	0.00844	0.0249	2532	7470.	(25.32, 70.02)
B	(330.0, 45.0)	75.0	(-1.25, +1.25)	2.5	0.01416	0.024166	4250	7250.	(42.5, 72.5)
ECO	(130.05, 237.45)	107.4	(-1, +49.85)	50.85	0.00844	0.0249	2532	7470.	(25.32, 70.02)

The next table provides the number of mock catalogues per cubic box of  $L=180$  Mpc/h.

Survey	N Mocks
Resolve A	59
Resolve B	104
ECO	8

## Mock Catalogues

The mock catalogues have the same geometries as those of the real surveys. The mock catalogues consist of a total of **26**

**columns**, each column providing information about the individual galaxy and its host DM halo, and properties from real galaxy catalogues. Aside from the values obtained from the simulation ( Columns 1-12), we matched properties from real catalogues (i.e. ECO and RESOLVE A/B) to the mock catalogues by finding the r-band absolute magnitude in real data that resembles that of the mock galaxy catalogues. For r-band absolute magnitudes between  $-17.33 < Mr \leq -17.00$ , we matched the mock galaxy's  $Mr$  to a galaxy in RESOLVE B (*resolvecatalogstr.fits* | Updated on 2015-07-16) For r-band absolute magnitudes brighter than  $Mr = -17.33$ , we matched the mock galaxy's  $Mr$  to a galaxy in ECO (*ecowresa\_050815.dat* | Updated on 2015-05-08). For each matched galaxy, we attached the galaxy's properties to the matched mock galaxy catalogue.

We also ran the Berling2006 Friends-of-Friends algorithm on each mock catalogue, and assigned an estimated mass to the galaxy group through *Halo Abundance Matching*.

For observables in the real data, the joint probability distributions are the same as those in the real data.

For all the values, we use the following cosmology:

```
Omega_M_0      : 0.302
Omega_lambda_0 : 0.698
Omega_k_0      : 0.0
h              : 0.698
```

For the Group finding, we used the following parameters and linking lengths:

```
Linking Parallel: 1.1
Linking Perpend.: 0.07
Nmin            : 1
```

## Columns

**Theory Columns : Columns 1 - 12**

**Observables Columns: Columns 13 - 20**

**Group Columns : Columns 21 - 25**

1. **Right Ascension** : RA of the individual galaxy, given in *degrees*
2. **Declination** : Declination of the ind. galaxy, given in *degrees*
3. **CZ\_Obs** : Velocity of the galaxy ( *with* redshift distortions), given in *km/s*
4. **Mr** : Galaxy's magn. in the r-band. Calculated using a CLF approach, but using real photometry from survey.
5. **Halo ID** : DM Halo identification number, as taken from the simulation
6. **log(MHalo)** : Logarithmic value of the DM Halo's Mass, as **log( MHalo / (Msun/h) )** with  $h=0.698$ .
7. **NGals\_h** : Total number of galaxies in DM halo. Number of galaxies in the mock may differ from this value.
8. **Type** : Type of Galaxy, i.e. Central or Satellite. **Halo Central** = 1, **Halo Satellite** = 0.
9. **CZ\_Real** : Velocity of the galaxy ( *without* redshift distortions), given in *km/s*.
10. **Dist\_central** : *Real* Distance between Halo's center and the galaxy, in *Mpc*. Here, **Central galaxy = Halo's center**.

11. **Vp\_total** : Total value for peculiar velocity, given in *km/s*.
12. **Vp\_tang** : Tangential component of the peculiar velocity, given in *km/s*.
13. **Morphology** : Galaxy morphology. 'LT': *Late Type* ; 'ET': *Early Type*. Used either 'goodmorph' (ECO) or 'MORPH' (RESOLVE) keys. '-9999' if no matched galaxy.
14. **log Mstar** : Log value of Galaxy stellar mass in log *Msun*. Used either 'rpgoodmstarsnew' (ECO) or 'MSTARS' (RESOLVE) keys in the files.
15. **r-band mag** : Galaxy's r-band *apparent* magnitude. Used either 'rpsmoothrestmagnew' (ECO) or 'SMOOTHRESTRMAG' (RESOLVE) keys in the files.
16. **u-band mag** : Galaxy's u-band *apparent* magnitude. Used either 'rpsmoothrestumagnew' (ECO) or 'SMOOTHRESTUMAG' (RESOLVE) keys in the files.
17. **FSGMR** : Stellar mass produced over last Gyr divided by pre-existing Stellar mass from new model set. In (*1/Gyr*). Used 'rpmearnsfr' (ECO) or 'MODELFSGMR' (RESOLVE) keys.
18. **Match\_Flag** : Survey, from which the properties of the real matched galaxy were extracted. 'ECOgal' = Galaxy from ECO file. 'RESgal' = Galaxy from RESOLVE file.
19. **u-r color** : Color of the matched galaxy, i.e.  $u_{mag} - r_{mag}$  (Col 15 - Col 16).
20. **MHI mass** : HI mass in *Msun*. Used the *predicted HI* masses (matched to the ECO file, i.e. *ecowresa050815.dat* ) and the key 'MHI' for RESOLVE galaxies. To compute MHI masses using **ECO values**, we used the formula:  $10^{(MHI + \log Mstar)}$ . Units in *Msun*.
21. **Group ID** : Group ID, to which the galaxy belongs after running the Berlind2006 FoF group finder.
22. **Group NGals** : Number of galaxies in a group of galaxies.
23. **RG projected** : Projected radius of the group of galaxies. Units in *Mpc*.
24. **CZ Disp. Group** : Dispersion in velocities of galaxies in the group. Units in *km/s*.
25. **Abund. log MHalo** : Abundance matched mass of the group of galaxy. This was calculated by assuming a monotonic relation between dark matter halo mass (MHalo) and the group *total* luminosity. For RESOLVE B, we used a modified version of the ECO group luminosity function. Units in *Msun*.
26. **Group Gal. Type** : Type of group galaxy. **Group central** = 1, **Group Satellite** = 0.

The relationship between velocities (CZ's) is the following:

$$(CZ_{Obs} - CZ_{Real})^2 + (Vp_{tang})^2 = (Vp_{total})^2$$

## Halos Filaments

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### Columns

1. **Halo ID** : This corresponds to the Halo ID number for the given DM Halo in the simulation box.
2. **log(MHalo)** : Logarithmic value of the DM Halo's Mass, as  $\log( MHalo / (Msun/h) )$  with  $h = 1.0$

3. **ID / Type** : This is a flag that shows what the environment of the DM halo is. There are four options for this, i.e. a. ID = 0 ..... Not in a filament b. ID = 1 ..... A filament node c. ID = 2 ..... Part of a filament skeleton d. ID = 3 ..... within a close radius of a filament
4. **Fil.** : The ID of the filament the halo belongs to ( -1 if it is not in a filament).
5. **Fil. Quality**: The quality of the filament (i.e. probability that the filament is real).

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## Project Organization

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## References

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