astrodatapy Documentation

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CONTENTS

This is the documentation for astrodatapy. A collective framework of astronomical data.

Part I

AstroDataPy Documentation

This is the documentation for astrodatapy.

CHAPTER

ONE

ASTRODATAPY

Python tools to collect astronomical data.

This is a python package dedicated to collect up-to-date astronomical data from both observational and modelling campaigns, with a focus on galaxy properties. Current package includes 1) statistical properties such as the number densities of galaxies (as functions of stellar mass, UV magnitude, star formation rate) and AGN (as functions of black hole mass, quasar UV/optical/bolometric luminosities); 2) correlations between galaxies properties such as the Magorrian relation, Tully Fisher relation, Disk size - stellar mass relation, and halo - stellar mass relation, etc; and 3) clustering of quasars such as the two point correlation function.

Current modelling results include DRAGONS (Meraxes).

CHAPTER

TWO

INSTALLATION

```
$ pip install git+https://github.com/qyx268/astrodatapy
```

CHAPTER

THREE

USAGE

3.1 Example 1

read quasar two point correlation function at z = 4 with a redshift range of [3.5, 4.5]

```
>>> from astrodatapy.clustering import clustering
>>> obs = clustering(feature = 'QC_2PTCF', z_target = 4.0, z_tol = 0.5)
    You are requesting QC_2PTCF at z_target=4.00 with a tolerance of z_tol=0.50 and h=1.000
    quiet=True to silent
    available data of QC_2PTCF includes:
    Shen2007 Shen2009 He2018 Eftekharzadeh2015 Chehade2016 Retana-Montenegro2016

    Loading observational data from He2018...
    Filename /home/yqin/.local/lib/python3.6/site-packages/astrodatapy-0.0.dev29-py3.6.egg/
↪astrodatapy/data//QC_2PTCF/z3pt8.dat
    ..done
>>> # show all available data of QC_2PTCF
>>> print(obs.available_observation)
    ['Shen2007' 'Shen2009' 'He2018' 'Eftekharzadeh2015' 'Chehade2016'
    'Retana-Montenegro2016']
>>> # show redshifts of all available data of QC_2PTCF
>>> print(obs.z_available_observation)
    [0.6 1.5 3.8 2.5 3.2 4.5]
>>> # show the target data of QC_2PTCF at z = 4
>>> print(obs.target_observation)
                        DataType   FileName                                                ␣
↪Data
    Name
    He2018  PowerLaw_2COMPONENTS  z3pt8.dat  [[0.10115794542598985, 6345.99167885821, 12459..
↪.
```

3.2 Example 2

read Magorrian Relation at redshift 0, output with h=0.678, and do not show information

```
>>> from astrodatapy.correlation import correlation
>>> obs = correlation(feature = 'Magorrian', z_target = 0, quiet = 1, h = 0.678)
```

3.3 Example 3

plot galaxy stellar mass function at redshift 5 and show labels

```
>>> import matplotlib.pyplot as plt
>>> from astrodatapy.number_density import number_density
>>> colors     = ['#e41a1c','#377eb8','#4daf4a','#984ea3','#ff7f00','#a65628','#f781bf','
↪#999999'] * 4
>>> markers    = ['o','s','v','^','<','>','p','*','D','.','8'] * 4
>>> linestyles = ['-','--','-.',':']
>>>
>>> z    = 5.0
>>> obs = number_density(feature = 'GSMF', z_target = 5.0, quiet = 1, h=0.678)
>>>
>>> j_data = 0
>>> k_func = 0
>>> fig, ax = plt.subplots(1, 1)
>>> for ii in range(obs.n_target_observation):
>>>     data       = obs.target_observation['Data'][ii]
>>>     label      = obs.target_observation.index[ii]
>>>     datatype   = obs.target_observation['DataType'][ii]
>>>     color      = colors[ii]
>>>     marker     = markers[j_data]
>>>     linestyle  = linestyles[k_func]
>>>     data[:,1:] = np.log10(data[:,1:])
>>>     if datatype == 'data':
>>>         ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
>>>                     label=label,color=color,fmt=marker)
>>>         j_data +=1
>>>     elif datatype == 'dataULimit':
>>>         ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
>>>                     label=label,color=color,fmt=marker)
>>>         j_data +=1
>>>     else:
>>>         ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
>>>         ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
>>>         k_func +=1
>>>
>>> ax.set_xlim(7, 13)
>>> ax.set_ylim(-7, -0.5)
>>> ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
>>>       verticalalignment='top',transform=ax.transAxes)
>>> leg = ax.legend(loc='lower left')
```

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```
>>> leg.get_frame().set_alpha(0.5)
>>> ax.set_xlabel(r"$\log_{10}[M_*/{\rm M_{\odot}}]$")
>>> ax.set_ylabel(r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$")
>>> plt.savefig('./GSMF.png',bbox_inches='tight')
```

More examples can be found in this jupyter notebook.

CHAPTER

FOUR

DOCUMENTATION

http://astrodatapy.readthedocs.io

CHAPTER

FIVE

FEATURES

5.1 Number density

Features	Descriptions
BHM	Black Hole Mass
BHMF	Black Hole Mass Function
GLF_UV	Galaxy Luminosity Function – UV
GSMF	Galaxy Stellar Mass Function – all
GSMF_Blue	Galaxy Stellar Mass Function – blue
GSMF_Bulge	Galaxy Stellar Mass Function – bulge
GSMF_Disk	Galaxy Stellar Mass Function – disk
GSMF_Quiescent	Galaxy Stellar Mass Function – quiescent
GSMF_Red	Galaxy Stellar Mass Function – red
QLF_bolometric	Quasar Luminosity Function – bolometric
QLF_optical	Quasar Luminosity Function – optical
QLF_UV	Quasar Luminosity Function – UV
SFRF	Star Formation Rate Function

5.2 Correlation

Features	Descriptions
BHM	Black Hole Mass
Magorrian	Black Hole - Galaxy Bulge Mass Scaling Relation
Tully_Fisher	Mass - Velocity of Spiral Galaxies
DiskSize_StellarMass	DiskSize - StellarMass
GasFraction_StellarMass	GasFraction - StellarMass
sSFR_StellarMass_Blue	sSFR - StellarMass – blue
HaloMass_StellarMass	HaloMass - StellarMass
HaloMass_StellarMass_Blue	HaloMass - StellarMass – blue
HaloMass_StellarMass_Red	HaloMass - StellarMass – red

5.3 Clustering

Features	Descriptions
QC_2PTCF	Quasar Clustering – 2 point correlation function

CHAPTER

SIX

LICENSE

- Free software: BSD license
- This project is Copyright (c) Yuxiang Qin and licensed under the terms of the BSD 3-Clause license. See the licenses folder for more information.

CHAPTER

SEVEN

CONTRIBUTORS

- Yuxiang Qin (The University of Melbourne)

CHAPTER

EIGHT

EXAMPLES

Table of Contents

[1]:
```
import matplotlib
%matplotlib inline
import matplotlib.pyplot as plt
from matplotlib.colors import LogNorm
from astrodatapy.number_density import number_density
from astrodatapy.correlation    import correlation
from astrodatapy.clustering     import clustering

cosmo = {'omega_M_0' : 0.308,
'omega_lambda_0' : 0.692,
'omega_b_0' : 0.04839912,
'omega_n_0' : 0.0,
'N_nu' : 0,
'h' : 0.678,
'n' : 0.968,
'sigma_8' : 0.815
}

plt.rc('font', size=15)          # controls default text sizes
plt.rc('axes', titlesize=15)     # fontsize of the axes title
plt.rc('axes', labelsize=15)     # fontsize of the x and y labels
plt.rc('xtick', labelsize=12)    # fontsize of the tick labels
plt.rc('ytick', labelsize=12)    # fontsize of the tick labels
plt.rc('legend', fontsize=12)    # legend fontsize

colors         = ['#e41a1c','#377eb8','#4daf4a','#984ea3',\
                  '#ff7f00','#a65628','#f781bf','#999999']*4
color_maps     = ['Reds', 'Blues', 'Greens'] *4
markers        = ['o','s','v','^','<','>','p','*','D','.','8']*4
linestyles     = ['-','--','-.',':']*4
```

8.1 GSMF

Galaxy Stellar Mass Function

8.1.1 example

[2]:
```
obs = number_density(feature='GSMF', z_target=5.0, h=cosmo['h'])
print("Available Observations:")
obs.info
```

```
You are requesting GSMF at z_target=5.00 with a tolerance of z_tol=0.25 and h=0.678
quiet=True to silent
available data of GSMF includes:
Bell2003 Cole2001 Drory2009 Marchesini2009 Mortlock2011 Stefanon2017 Thanjavur2016␣
↪Grazian2015 Gonzalez2011 Duncan2014 Katsianis2015 Song2016 Davidzon2017 Santini2012␣
↪Ilbert2013 Muzzin2013 Huertas-Company2016 Tomczak2014 Pozzetti2007 Baldry2012 Caputi2011␣
↪Kajisawa2009 Perez-Gonzalez2008 Pozzetti2010 Yang2009 Qin2017_Tiamat Qin2017_Tiamat125_HR

Loading observational data from Stefanon2017. . .
```

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```
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
Converting IMF from Chabrier to Salpeter
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from ULDeltas to Upper Lower Limits
Converting the Normalization of Phi from 1.00e-05 to 1
Converting x axis from h=0.700 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.700 to h=0.678 with a power of 3
..done

Loading observational data from Grazian2015. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
WARNING! No Infomation about MAG, dafault is Salpeter
Converting x axis from h=0.700 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.700 to h=0.678 with a power of 3
..done

Loading observational data from Gonzalez2011. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from LUDeltas to Upper Lower Limits
Converting Phi from logarithm to linear
Converting x axis from h=1.000 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=1.000 to h=0.678 with a power of 3
..done

Loading observational data from Duncan2014. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
Converting IMF from Chabrier to Salpeter
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from LUDeltas to Upper Lower Limits
Converting x axis from h=0.700 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.700 to h=0.678 with a power of 3
..done

Loading observational data from Katsianis2015. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from Delta to Upper Lower Limits
Converting Phi from logarithm to linear
Converting x axis from h=0.702 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.702 to h=0.678 with a power of 3
..done

Loading observational data from Song2016. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
WARNING! No Infomation about MAG, dafault is Salpeter
```

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```
Converting the Errors from ULDeltas to Upper Lower Limits
Converting Phi from logarithm to linear
Converting x axis from h=0.700 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.700 to h=0.678 with a power of 3
..done

Loading observational data from Davidzon2017. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt0.dat
Using Schechter Function for Mass
Converting IMF from Chabrier to Salpeter
WARNING! No Infomation about MAG, dafault is Salpeter
Converting x axis from h=0.700 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.700 to h=0.678 with a power of 3
..done

Loading observational data from Qin2017_Tiamat. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt00.dat
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from Delta to Upper Lower Limits
Converting x axis from h=0.678 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.678 to h=0.678 with a power of 3
..done

Loading observational data from Qin2017_Tiamat125_HR. . .
Filename /home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/
↪astrodatapy/data//GSMF/z5pt00.dat
WARNING! No Infomation about MAG, dafault is Salpeter
Converting the Errors from Delta to Upper Lower Limits
Converting x axis from h=0.678 to h=0.678 with a power of -2 because it is GSMF
Converting y axis from h=0.678 to h=0.678 with a power of 3
..done
Available Observations:
```

[2]:

#Name	IMF	h	NormalizationOfPhi	Errors	Log	\
Bell2003	DietSalpeter	1.000	1.00000	LULimits	0	
Cole2001	Salpeter	1.000	1.00000	Delta	0	
Drory2009	Chabrier	0.700	1.00000	Delta	1	
Marchesini2009	Kroupa	0.700	1.00000	ULDeltas	1	
Mortlock2011	Salpeter	0.700	1.00000	Delta	1	
Stefanon2017	Chabrier	0.700	0.00001	ULDeltas	0	
Thanjavur2016	Chabrier	0.700	1.00000	ULDeltas	1	
Grazian2015	Salpeter	0.700	1.00000	ULLimits	0	
Gonzalez2011	Salpeter	1.000	1.00000	LUDeltas	1	
Duncan2014	Chabrier	0.700	1.00000	LUDeltas	0	
Katsianis2015	Salpeter	0.702	1.00000	Delta	1	
Song2016	Salpeter	0.700	1.00000	ULDeltas	1	
Davidzon2017	Chabrier	0.700	1.00000	None	0	
Santini2012	Salpeter	0.700	1.00000	None	0	
Ilbert2013	Chabrier	0.700	1.00000	None	0	

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```
Muzzin2013                 Kroupa  0.700            1.00000      None    0
Huertas-Company2016       Chabrier  0.700            1.00000      None    0
Tomczak2014               Chabrier  0.700            1.00000  ULDeltas    1
Pozzetti2007              Chabrier  0.700            1.00000      None    0
Baldry2012                Chabrier  0.678            1.00000  ULDeltas    1
Caputi2011                Chabrier  0.678            1.00000  ULDeltas    1
Kajisawa2009              Chabrier  0.678            1.00000  ULDeltas    1
Perez-Gonzalez2008        Chabrier  0.678            1.00000  ULDeltas    1
Pozzetti2010              Chabrier  0.678            1.00000  ULDeltas    1
Yang2009                  Chabrier  0.678            1.00000  ULDeltas    1
Qin2017_Tiamat            Salpeter  0.678            1.00000     Delta    0
Qin2017_Tiamat125_HR      Salpeter  0.678            1.00000     Delta    0

                      HinPhi       Type        Bibliographic
#Name
Bell2003                   0       data  2012MNRAS.421..621B
Cole2001                   0       data  2001MNRAS.326..255C
Drory2009                  0       data  2009ApJ...707.1595D
Marchesini2009             0       data  2009ApJ...701.1765M
Mortlock2011               0       data  2011MNRAS.413.2845M
Stefanon2017               0       data  2017ApJ...843...36S
Thanjavur2016              0       data  2016MNRAS.459...44T
Grazian2015                0       data  2015A&A...575A..96G
Gonzalez2011               0       data  2011ApJ...735L..34G
Duncan2014                 0       data  2014MNRAS.444.2960D
Katsianis2015              0   data_sim  2015MNRAS.448.3001K
Song2016                   0       data  2016ApJ...825...5S
Davidzon2017               0  Schechter  2017A&A...605A..70D
Santini2012                0  Schechter  2012A&A...538A..33S
Ilbert2013                 0  Schechter  2013A&A...556A..55I
Muzzin2013                 0  Schechter  2013ApJ...777...18M
Huertas-Company2016        0  Schechter  2016MNRAS.462.4495H
Tomczak2014                0       data  2014ApJ...783...85T
Pozzetti2007               0  Schechter  2007A&A...474..443P
Baldry2012                 0       data  2012MNRAS.421..621B
Caputi2011                 0       data  2011MNRAS.413..162C
Kajisawa2009               0       data  2009ApJ...702.1393K
Perez-Gonzalez2008         0       data  2008ApJ...675..234P
Pozzetti2010               0       data  2010A&A...523A..13P
Yang2009                   0       data  2009ApJ...695..900Y
Qin2017_Tiamat             0   data_sim  2017MNRAS.472.2009Q
Qin2017_Tiamat125_HR       0   data_sim  2017MNRAS.472.2009Q
```

[3]:
```
print("Target Observations:")
obs.target_observation
```

```
Target Observations:
```

[3]:
```
                       DataType    FileName  \
Name
Stefanon2017               data   z5pt0.dat
Grazian2015                data   z5pt0.dat
Gonzalez2011               data   z5pt0.dat
```

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```
Duncan2014                 data   z5pt0.dat
Katsianis2015          data_sim   z5pt0.dat
Song2016                   data   z5pt0.dat
Davidzon2017          Schechter   z5pt0.dat
Qin2017_Tiamat         data_sim  z5pt00.dat
Qin2017_Tiamat125_HR   data_sim  z5pt00.dat

                                                                  Data
Name
Stefanon2017          [[10.963009197397692, 8.632141819241988e-06, 2. . .
Grazian2015           [[9.097736692294387, 0.005088420440816329, 0.0. . .
Gonzalez2011          [[7.870060612265873, 0.001921715449346003, 0.0. . .
Duncan2014            [[9.002009197397692, 0.009041032747521872, 0.0. . .
Katsianis2015         [[7.825874836525483, 0.015909910816851603, 0.0. . .
Song2016              [[7.277736692294387, 0.03078895589910497, 0.05. . .
Davidzon2017          [[9.283009197397693, 0.0022312861848298765, 0. . .
Qin2017_Tiamat        [[7.05, 0.44436000000000025, 0.446467980000000. . .
Qin2017_Tiamat125_HR  [[7.05, 0.042807000000000026, 0.04306835900000. . .
```

8.1.2 all

[4]:
```
feature = 'GSMF'
xlim    = (7, 13)
ylim    = (-7, -0.5)
xlabel  = r"$\log_{10}[M_*/{\rm M_{\odot}}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [7, 5, 4, 2, 1.75, 1.3, 1.0, 0.6, 0.0]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
```

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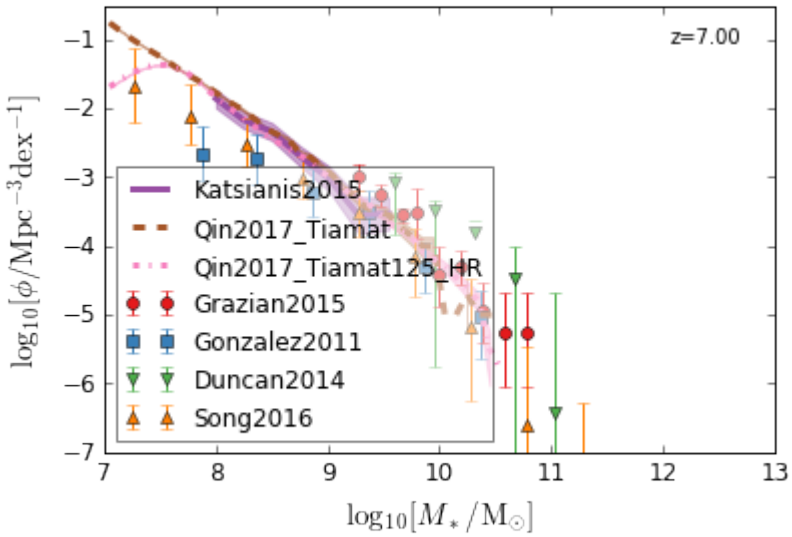
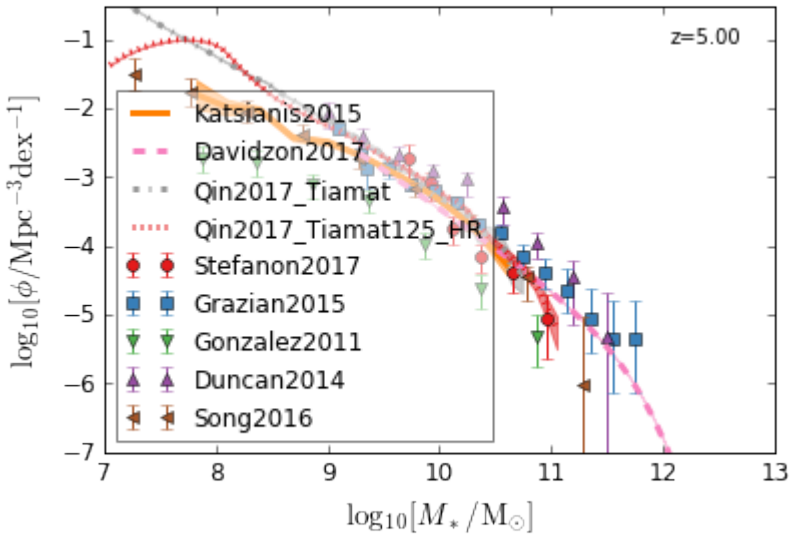
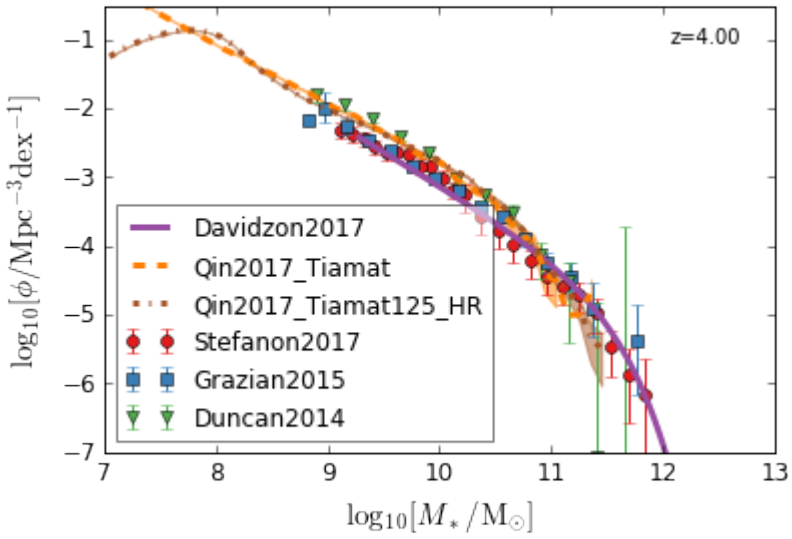
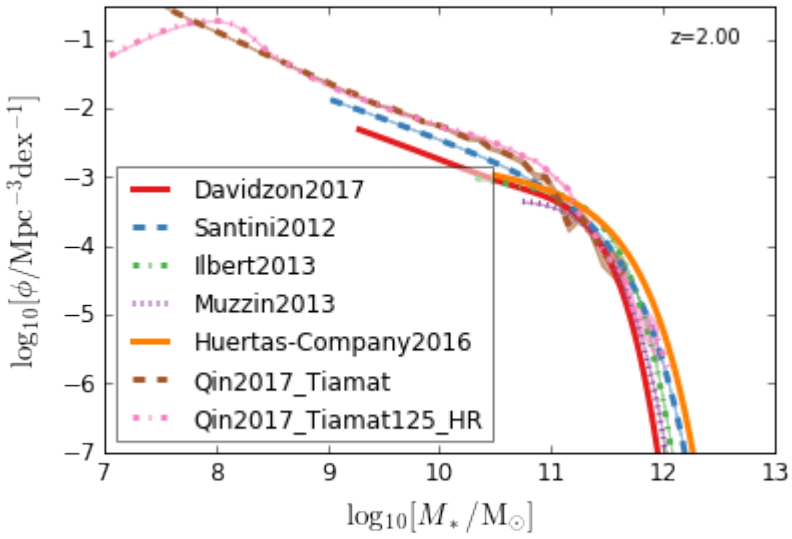
```
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

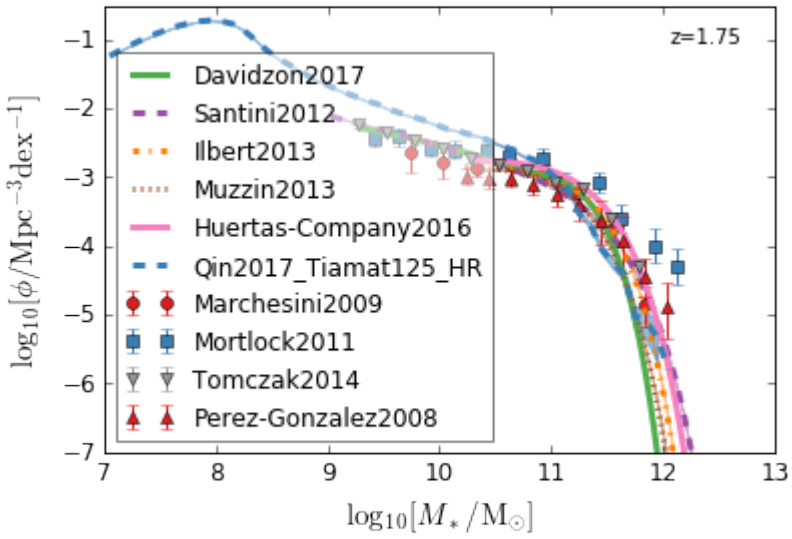
```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪divide by zero encountered in log10
```

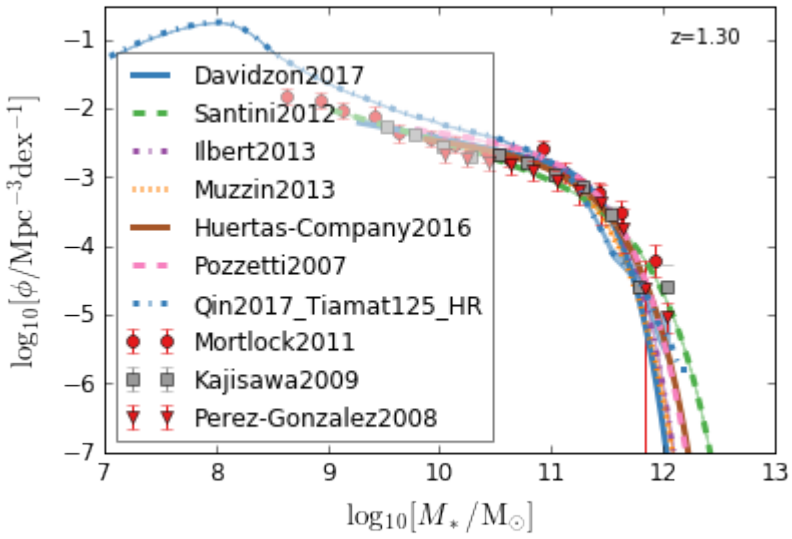


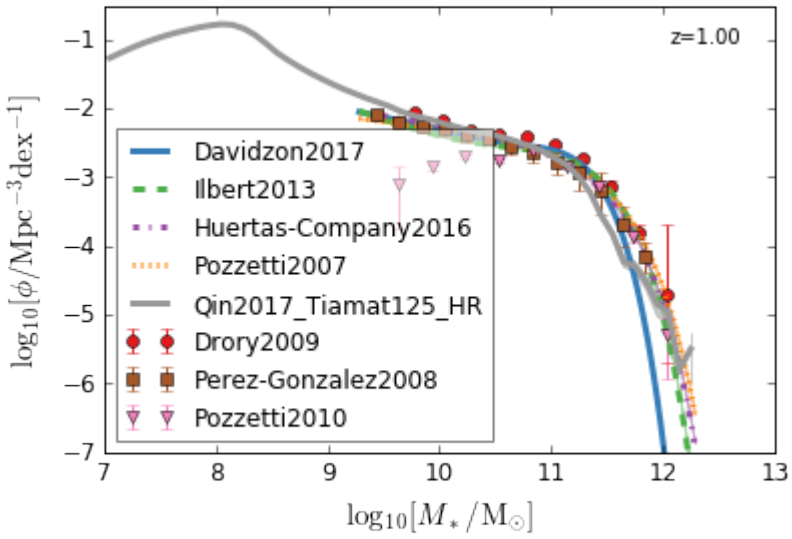


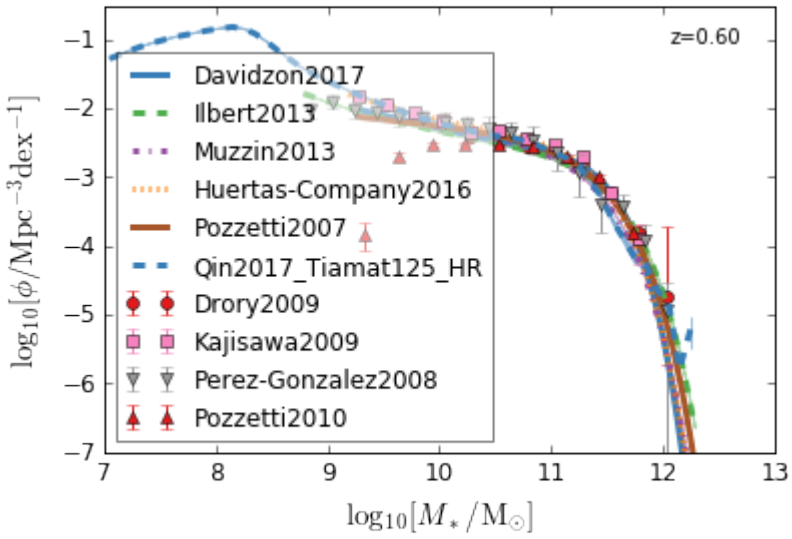

z=4.00
Davidzon2017
Qin2017_Tiamat
Qin2017_Tiamat125_HR
Stefanon2017
Grazian2015
Duncan2014
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$

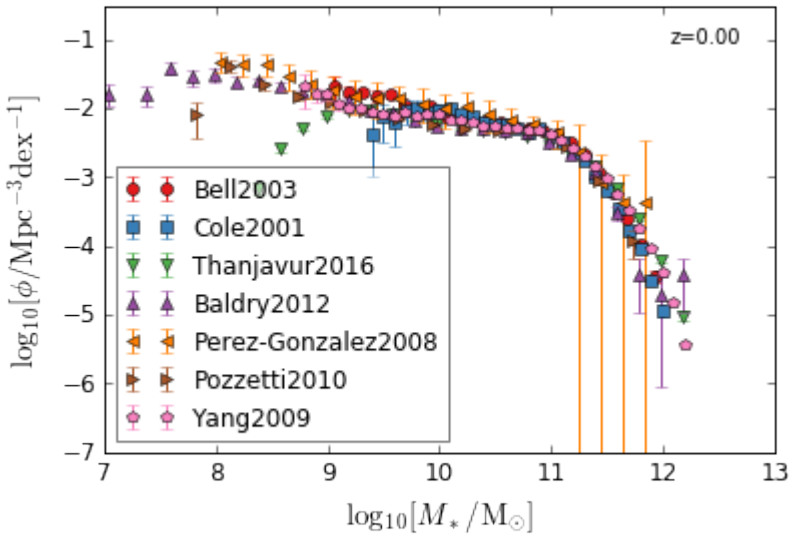

z=2.00
Davidzon2017
Santini2012
Ilbert2013
Muzzin2013
Huertas-Company2016
Qin2017_Tiamat
Qin2017_Tiamat125_HR
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=1.75
Davidzon2017
Santini2012
Ilbert2013
Muzzin2013
Huertas-Company2016
Qin2017_Tiamat125_HR
Marchesini2009
Mortlock2011
Tomczak2014
Perez-Gonzalez2008
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=1.30
Davidzon2017
Santini2012
Ilbert2013
Muzzin2013
Huertas-Company2016
Pozzetti2007
Qin2017_Tiamat125_HR
Mortlock2011
Kajisawa2009
Perez-Gonzalez2008
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=1.00
Davidzon2017
Ilbert2013
Huertas-Company2016
Pozzetti2007
Qin2017_Tiamat125_HR
Drory2009
Perez-Gonzalez2008
Pozzetti2010
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=0.60
Davidzon2017
Ilbert2013
Muzzin2013
Huertas-Company2016
Pozzetti2007
Qin2017_Tiamat125_HR
Drory2009
Kajisawa2009
Perez-Gonzalez2008
Pozzetti2010
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$



8.1.3 Blue & Red

[5]:
```
features = ['GSMF_Blue', 'GSMF_Red']
xlim     = (7, 13)
ylim     = (-7, -0.5)
xlabel   = r"$\log_{10}[M_*/{\rm M_{\odot}}]$"
ylabel   = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs       = [2.0, 0.0]

for z in [2.0,0.0]:
    fig,ax = plt.subplots(1,1)
    for feature, color in zip(features, ['Blue', 'Red']):
        obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
        for ii in range(obs.n_target_observation):
            data       = obs.target_observation['Data'][ii]
            label      = obs.target_observation.index[ii]
            datatype   = obs.target_observation['DataType'][ii]
            marker     = markers[ii]
            data[:,1:] = np.log10(data[:,1:])
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:17: RuntimeWarning:␣
↪divide by zero encountered in log10
```

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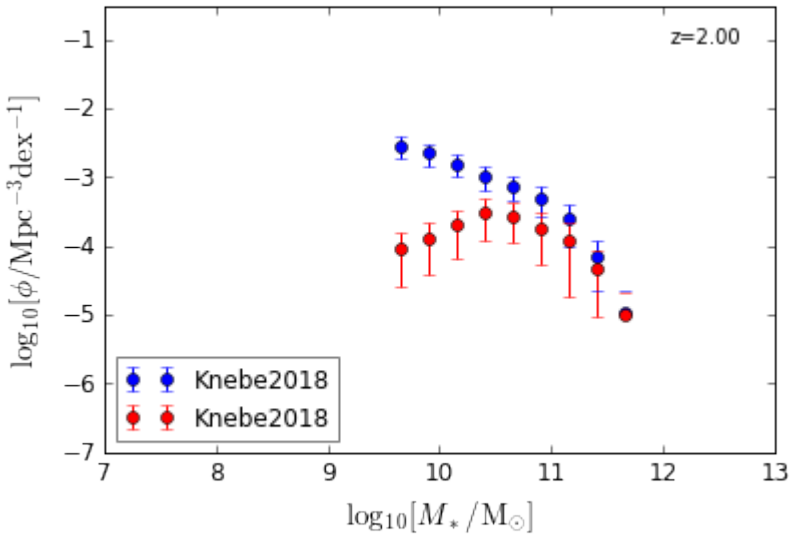

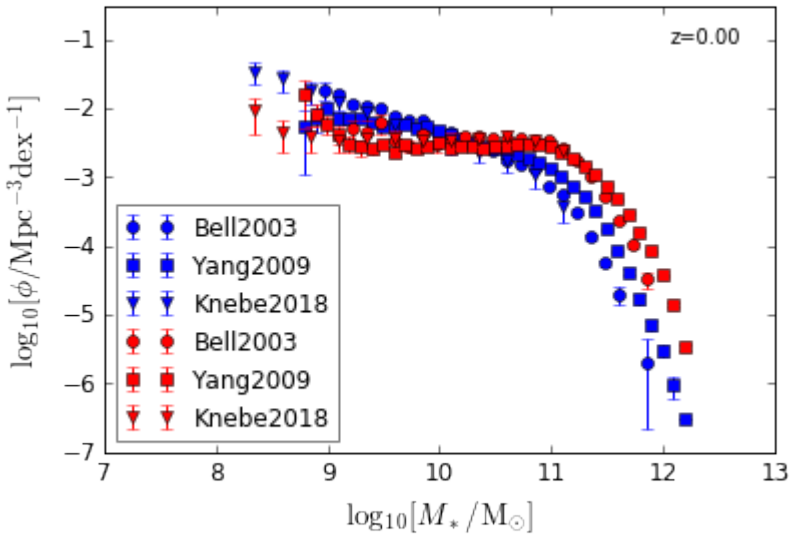

8.1.4 Disk & Bulge

[6]:
```
features = ['GSMF_Disk', 'GSMF_Bulge']
xlim     = (7, 13)
ylim     = (-7, -0.5)
xlabel   = r"$\log_{10}[M_*/{\rm M_{\odot}}]$"
ylabel   = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs       = [2.0, 0.0]

for z in [0.0,]:
    fig,ax = plt.subplots(1,1)
    for feature, color in zip(features, ['Blue', 'Red']):
        obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
```

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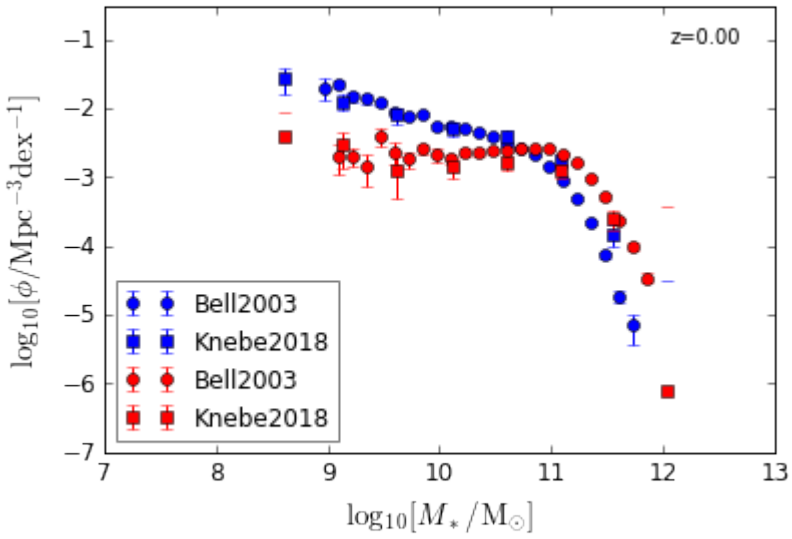
```
        for ii in range(obs.n_target_observation):
            data       = obs.target_observation['Data'][ii]
            label      = obs.target_observation.index[ii]
            datatype   = obs.target_observation['DataType'][ii]
            marker     = markers[ii]
            data[:,1:] = np.log10(data[:,1:])
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:17: RuntimeWarning:␣
↪divide by zero encountered in log10
```



8.1.5 Quiescent

[7]:
```
feature = 'GSMF_Quiescent'
xlim    = (7, 13)
ylim    = (-7, -0.5)
xlabel  = r"$\log_{10}[M_*/{\rm M_{\odot}}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [2.75,2.25,1.75]

for z in zs:
    fig,ax = plt.subplots(1,1)
```

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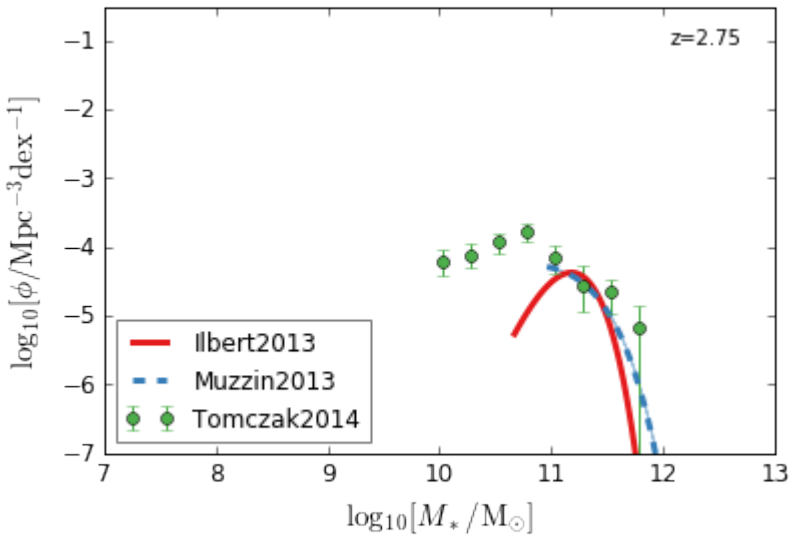
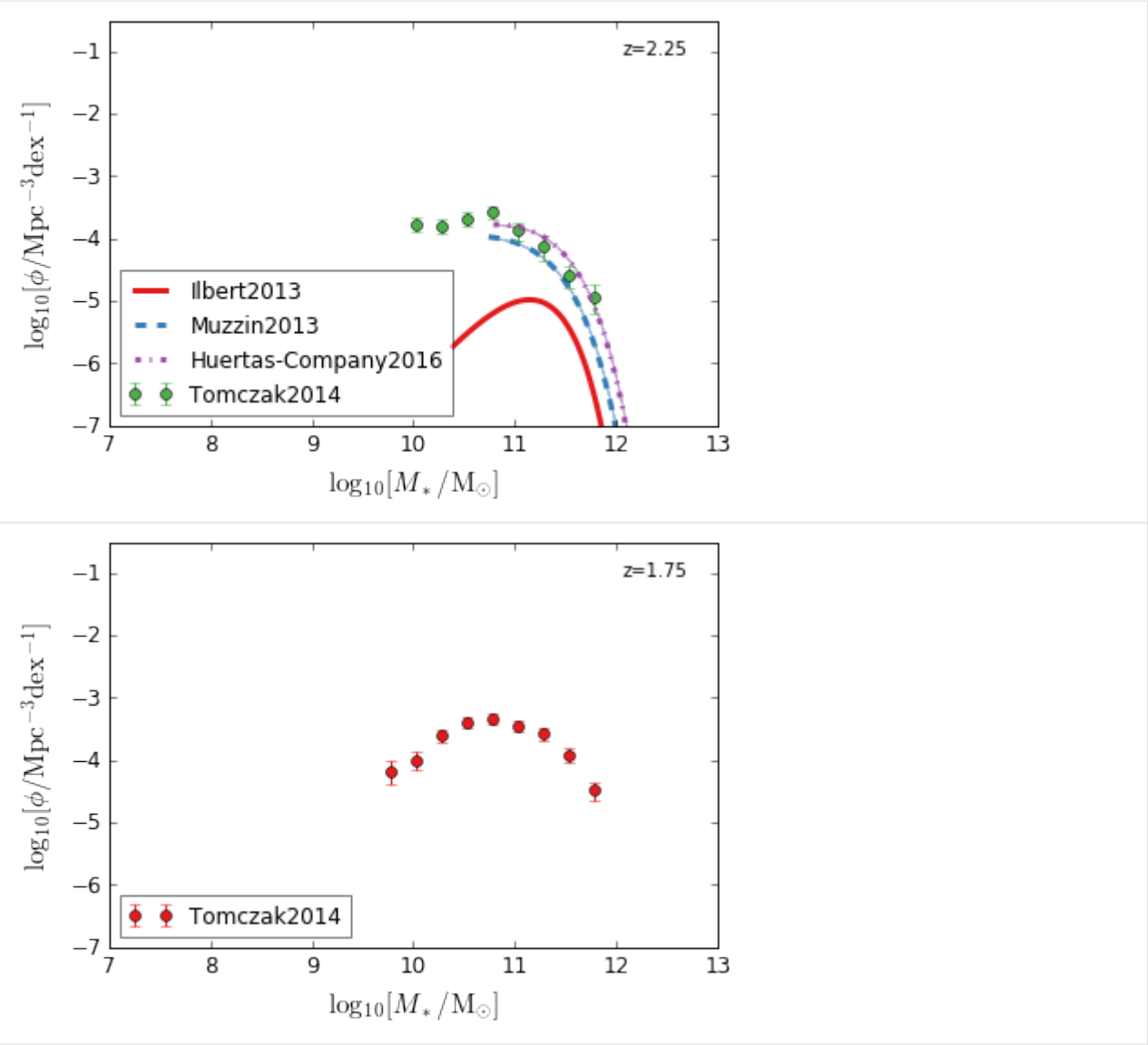
```
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```





8.2 SFRF

Star Formation Rate Function

[8]:
```
feature = 'SFRF'
xlim    = (-1, 3)
ylim    = (-6, -1)
xlabel  = r"$\log_{10}[\rm SFR/M_\odot yr^{-1}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [7,6,5,4]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
```

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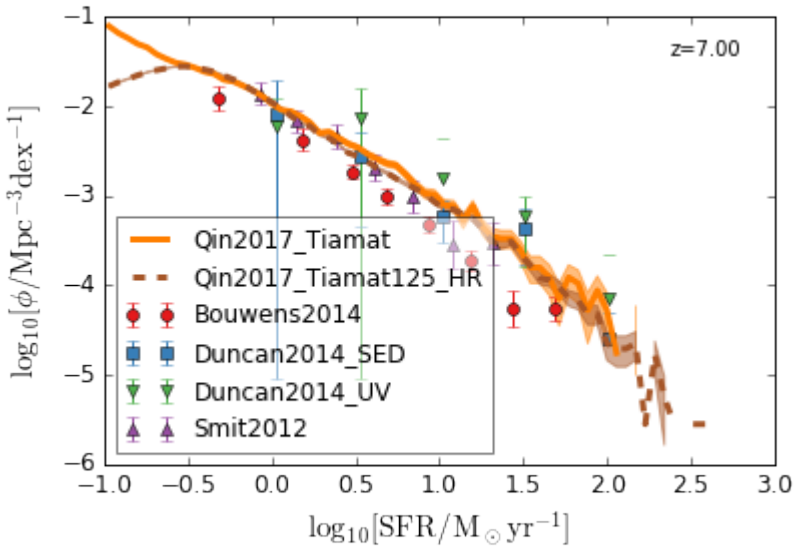
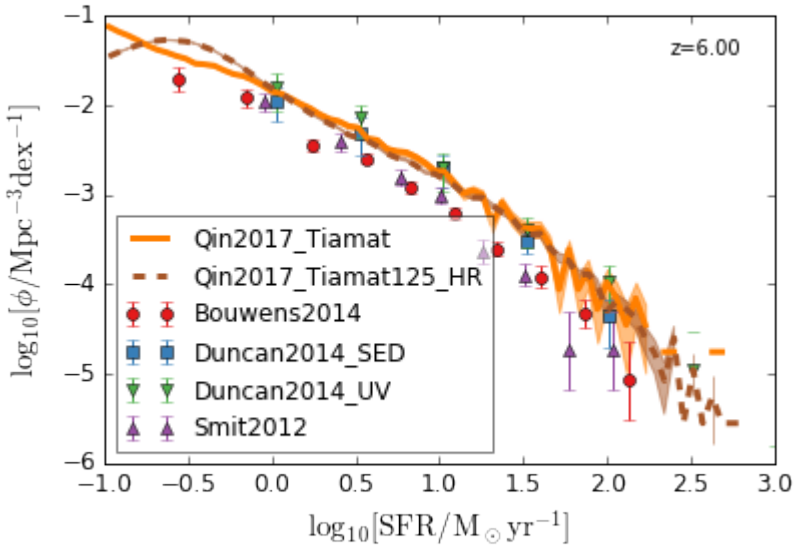
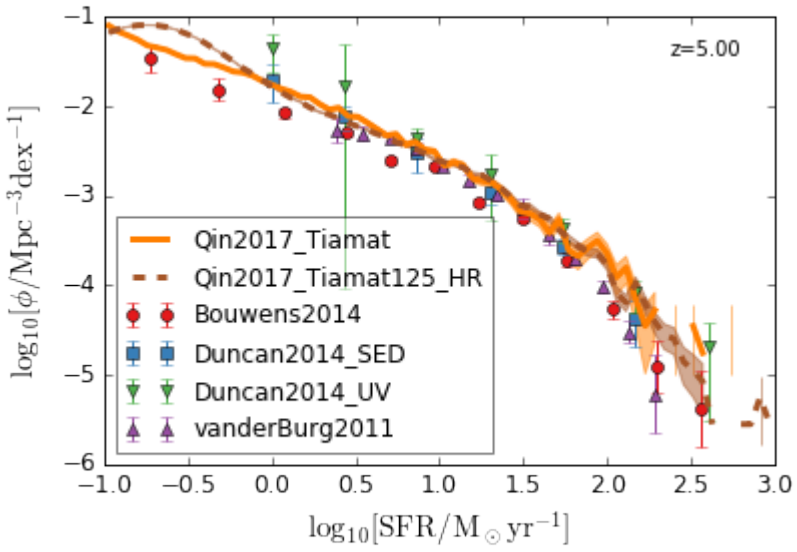
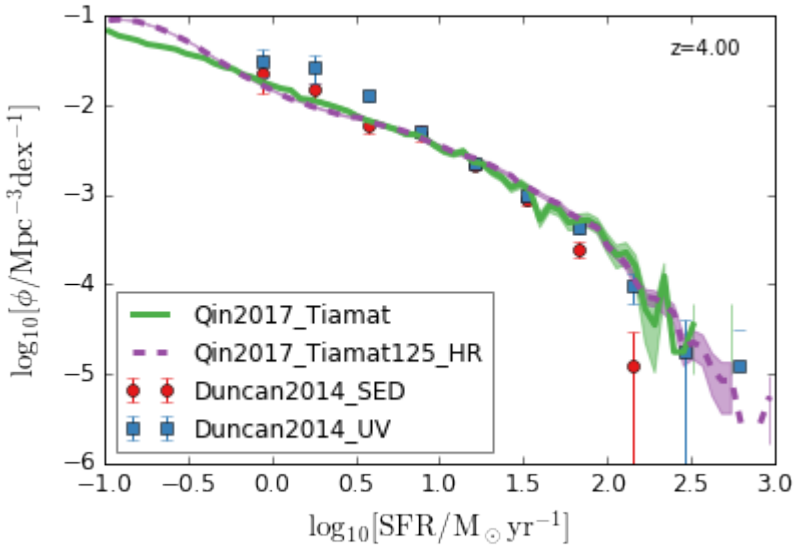
```
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪divide by zero encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:22: RuntimeWarning:␣
↪invalid value encountered in subtract
```


z=7.00
Qin2017_Tiamat
Qin2017_Tiamat125_HR
Bouwens2014
Duncan2014_SED
Duncan2014_UV
Smit2012
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[\mathrm{SFR}/\mathrm{M}_\odot\,\mathrm{yr}^{-1}]$


z=6.00
Qin2017_Tiamat
Qin2017_Tiamat125_HR
Bouwens2014
Duncan2014_SED
Duncan2014_UV
Smit2012
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[\mathrm{SFR}/\mathrm{M}_\odot\,\mathrm{yr}^{-1}]$





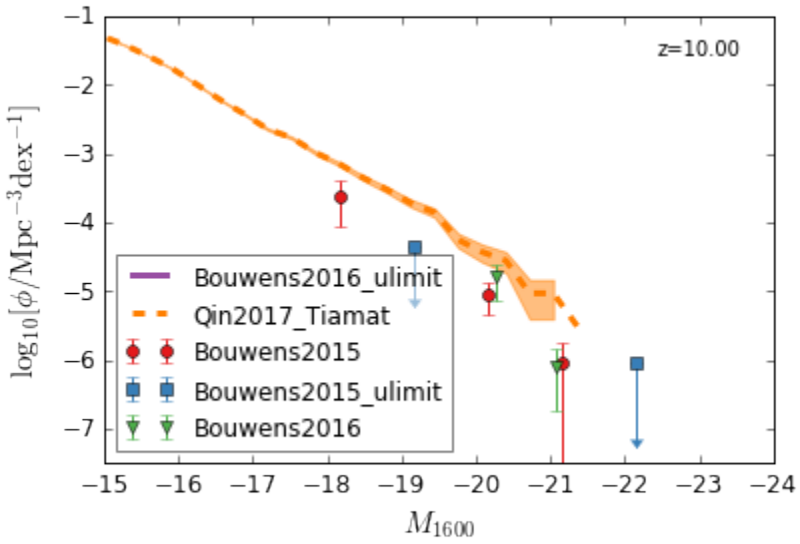
8.3 GLF

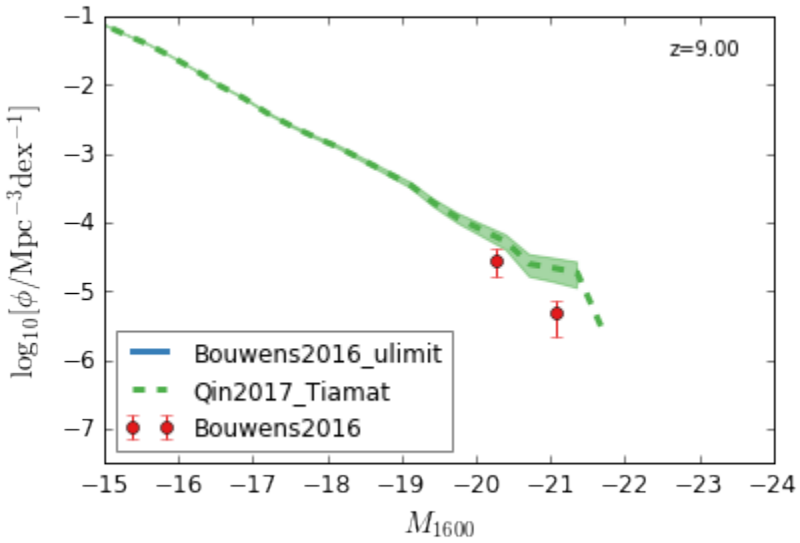
Galaxy Luminosity Function

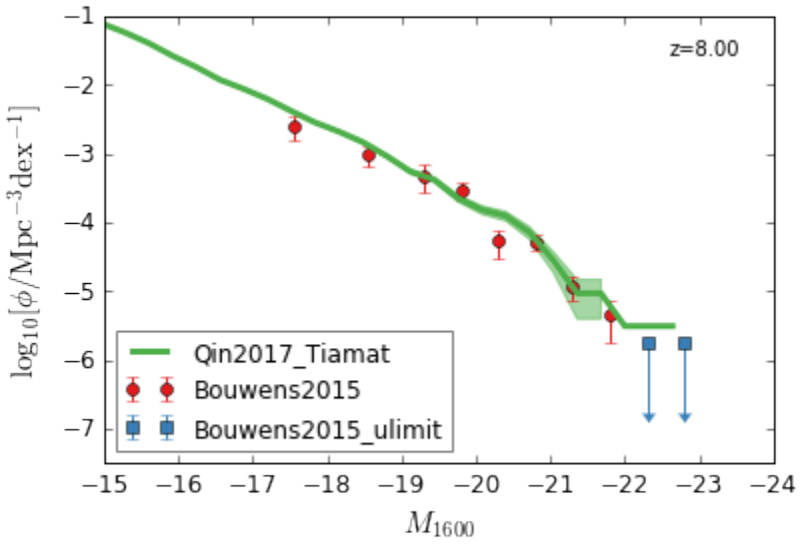
8.3.1 UV

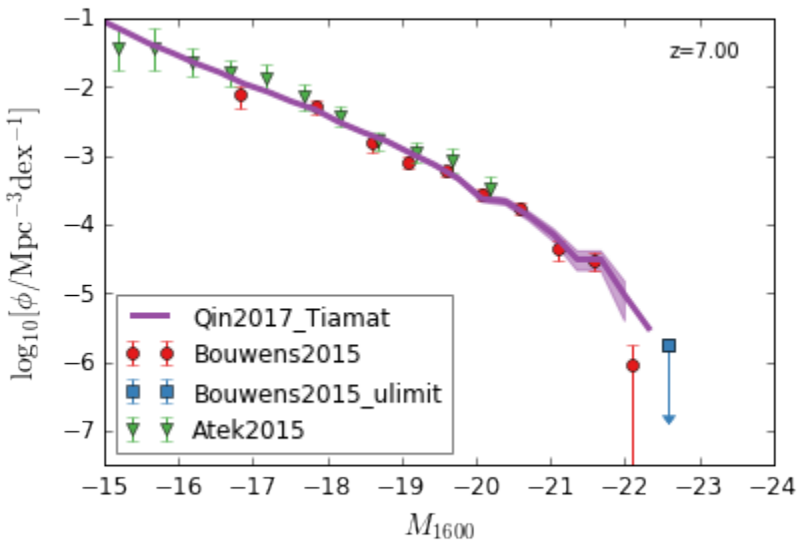
[9]:
```
feature = 'GLF_UV'
xlim    = (-15,-24)
ylim    = (-7.5,-1)
xlabel  = r"$M_{1600}$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [10,9,8,7,6,5,4,3]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

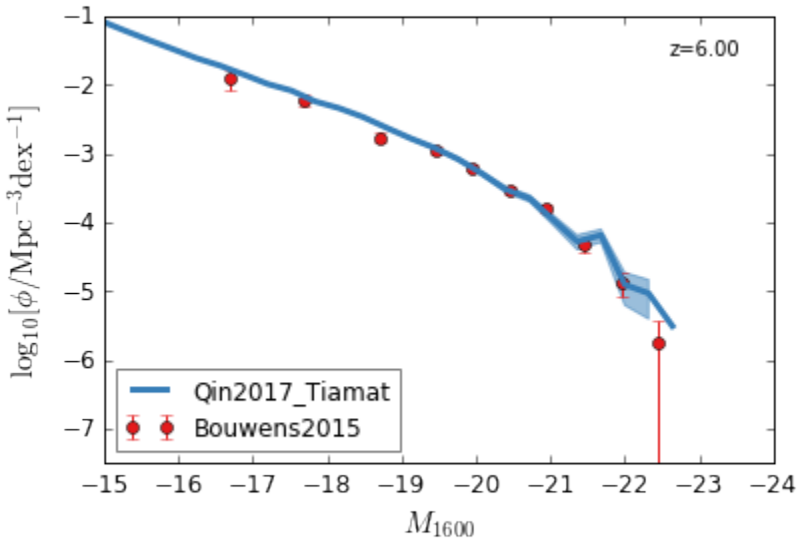
```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪invalid value encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪divide by zero encountered in log10
```

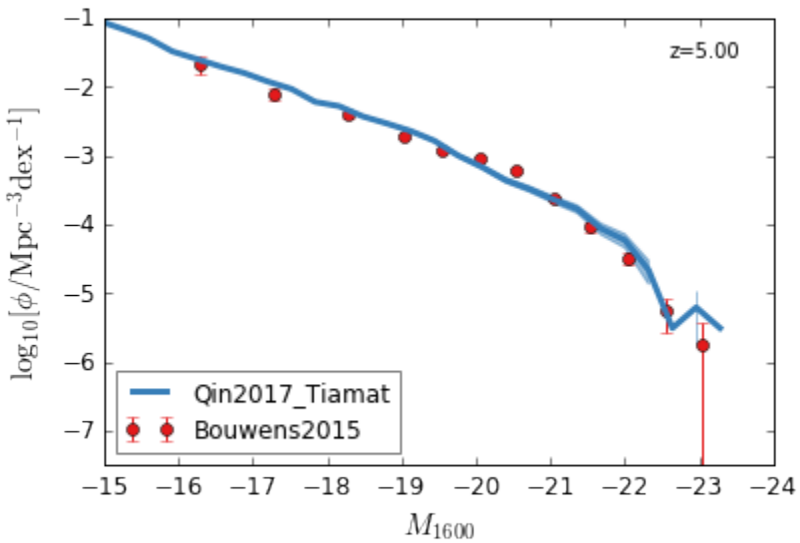

z=10.00
Bouwens2016_ulimit
Qin2017_Tiamat
Bouwens2015
Bouwens2015_ulimit
Bouwens2016
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}

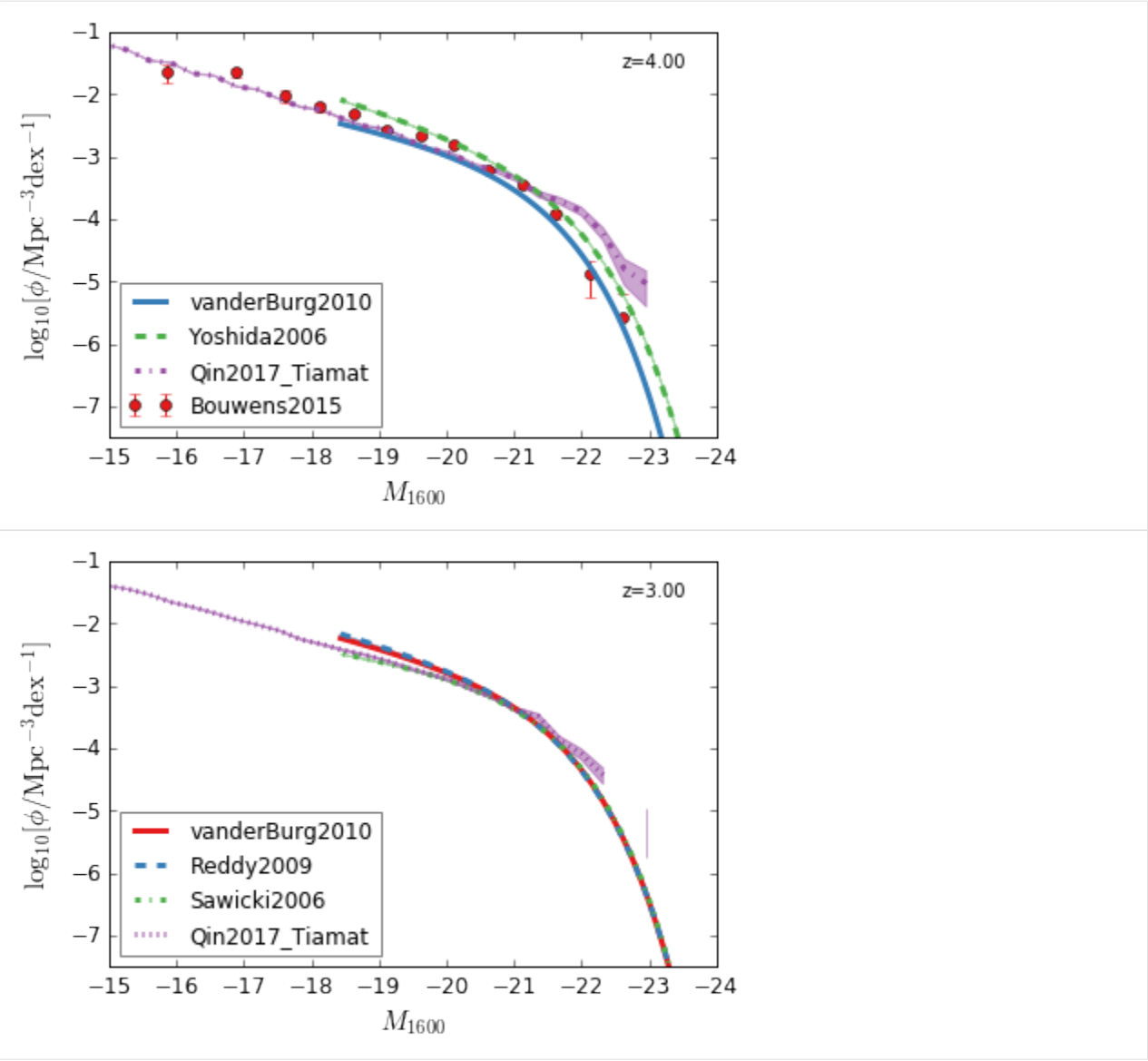

z=9.00
Bouwens2016_ulimit
Qin2017_Tiamat
Bouwens2016
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}


z=8.00
Qin2017_Tiamat
Bouwens2015
Bouwens2015_ulimit
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}


z=7.00
Qin2017_Tiamat
Bouwens2015
Bouwens2015_ulimit
Atek2015
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}


z=6.00
Qin2017_Tiamat
Bouwens2015
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}
−1
−2
−3
−4
−5
−6
−7
−15
−16
−17
−18
−19
−20
−21
−22
−23
−24


z=5.00
Qin2017_Tiamat
Bouwens2015
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_{1600}
−1
−2
−3
−4
−5
−6
−7
−15
−16
−17
−18
−19
−20
−21
−22
−23
−24



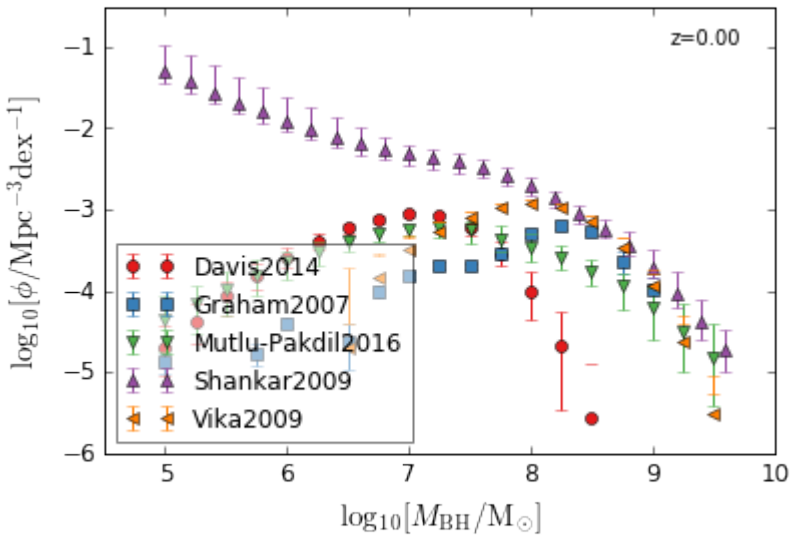
8.4 BHMF

Black Hole Mass Function

8.4.1 local

[10]:
```
feature = 'BHMF'
xlim    = (4.5, 10)
ylim    = (-6, -0.5)
xlabel  = r"$\log_{10}[M_{\rm BH}/{\rm M_{\odot}}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [0.0, ]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪divide by zero encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪invalid value encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:22: RuntimeWarning:␣
↪invalid value encountered in subtract
/home/yqin/3rd_party/lib/python3.6/site-packages/matplotlib/axes/_axes.py:2860:␣
↪RuntimeWarning: invalid value encountered in double_scalars
  high = [thisx + thiserr for (thisx, thiserr)
```



8.4.2 Shen et al. 2012

[11]:
```
feature = 'BHMF'
xlim    = (6, 11)
ylim    = (-15, -4)
xlabel  = r"$\log_{10}[M_{\rm BH}/{\rm M_{\odot}}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [0.4,0.6,0.8,1.0,1.2,1.4,1.6,1.8,2.15,2.65,3.2,3.75,4.25,4.75, ]

fig,ax = plt.subplots(1,1)
for z, color in zip(zs, colors):
    obs    = number_density(feature=feature,z_target=z,z_tol=0.05,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        if obs.target_observation.index[ii] != "Shen2012":
            continue
        data       = obs.target_observation['Data'][ii]
        label      = "z=%.2f"%z
        datatype   = obs.target_observation['DataType'][ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker,markersize=1)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
```

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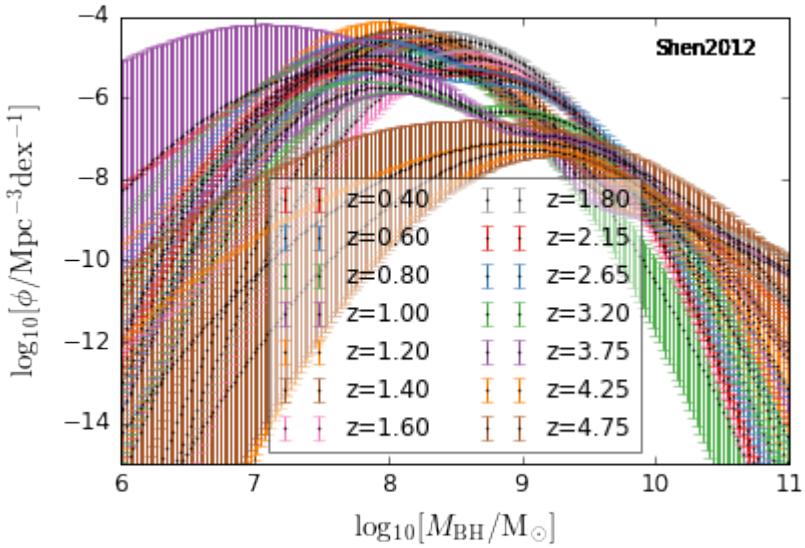
```
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "Shen2012",horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower center', ncol=2)
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```



8.4.3 DRAGONS

[12]:
```
feature = 'BHMF'
xlim    = (4, 10)
ylim    = (-6, 0)
xlabel  = r"$\log_{10}[M_{\rm BH}/{\rm M_{\odot}}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [0.55,0.95,2.0,5.0,7.0]

fig,ax = plt.subplots(1,1)
for z, color in zip(zs, colors):
    obs    = number_density(feature=feature,z_target=z,z_tol=0.05,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        if "Qin" not in obs.target_observation.index[ii]:
            continue
        data       = obs.target_observation['Data'][ii]
```

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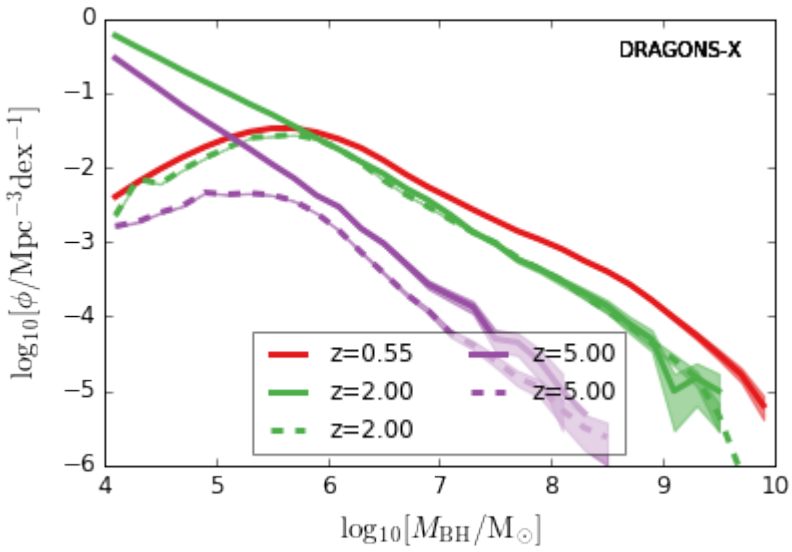
```
        label      = "z=%.2f"%z
        datatype   = obs.target_observation['DataType'][ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker,markersize=1)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "DRAGONS-X",horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower center', ncol=2)
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
No available data of BHMF at 0.90<z_target<1.00
No available data of BHMF at 6.95<z_target<7.05
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:21: RuntimeWarning:␣
↪divide by zero encountered in log10
```



8.5 QLF

Quasar Luminosity Function

8.5.1 UV

[13]:
```
feature = 'QLF_UV'
xlim    = (-15, -29)
ylim    = (-10, -3.5)
xlabel  = r"$M_{1450}$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [6,5,4,3]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪invalid value encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪divide by zero encountered in log10
```

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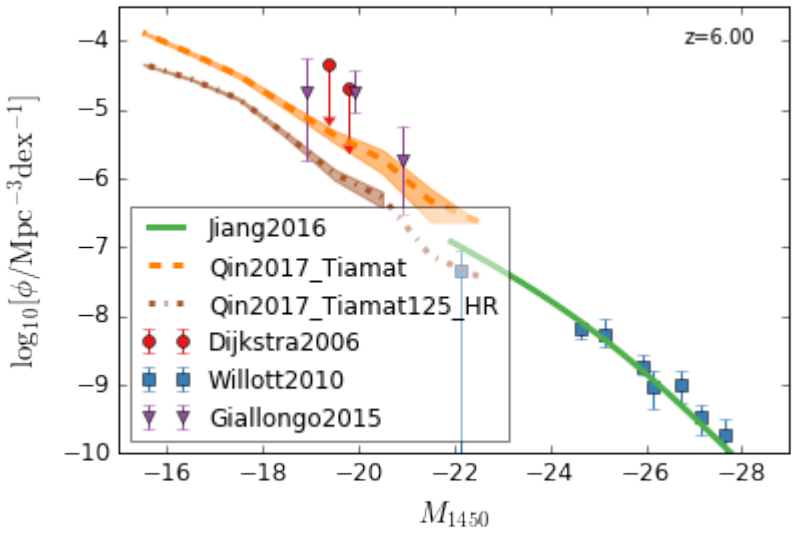

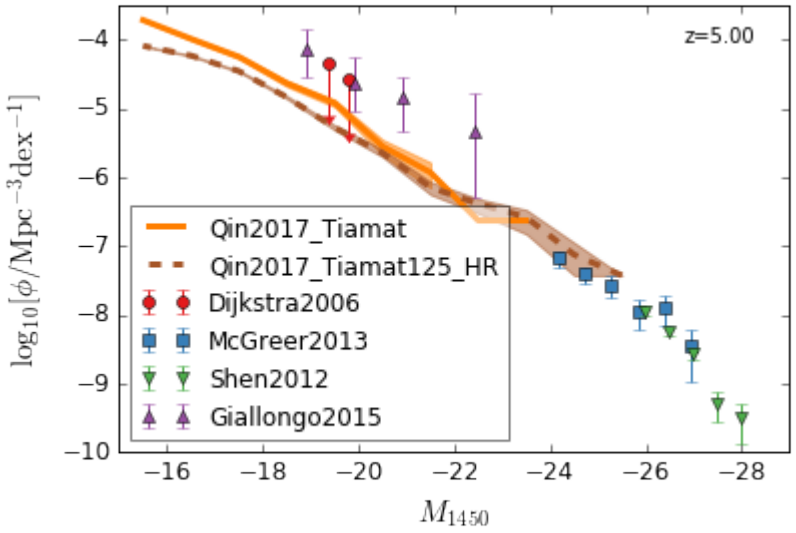

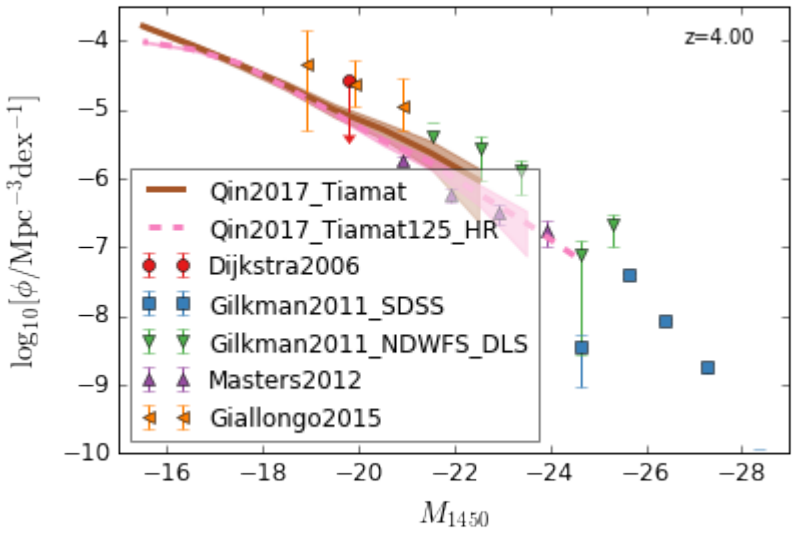

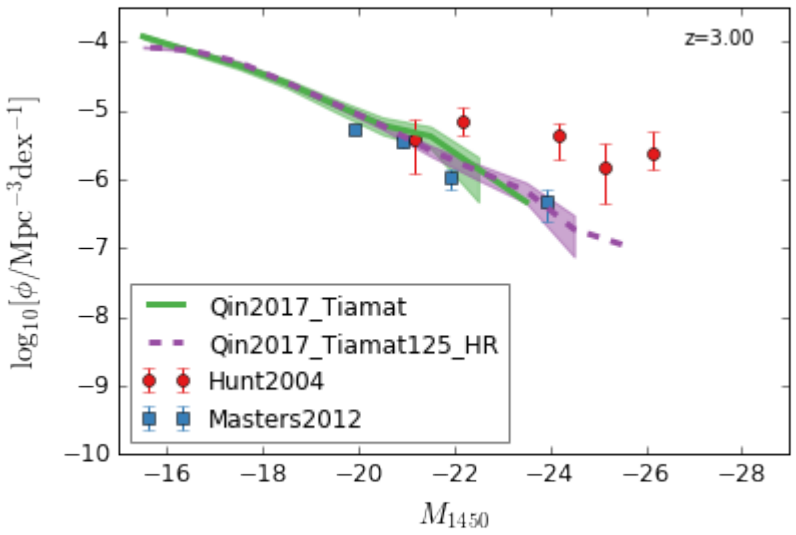

8.5.2 optical B

[14]:
```
feature = 'QLF_optical'
xlim    = (-15, -29)
ylim    = (-10, -3.5)
xlabel  = r"$M_{\rm B}$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [2,1.5,1.3,0.5]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
```

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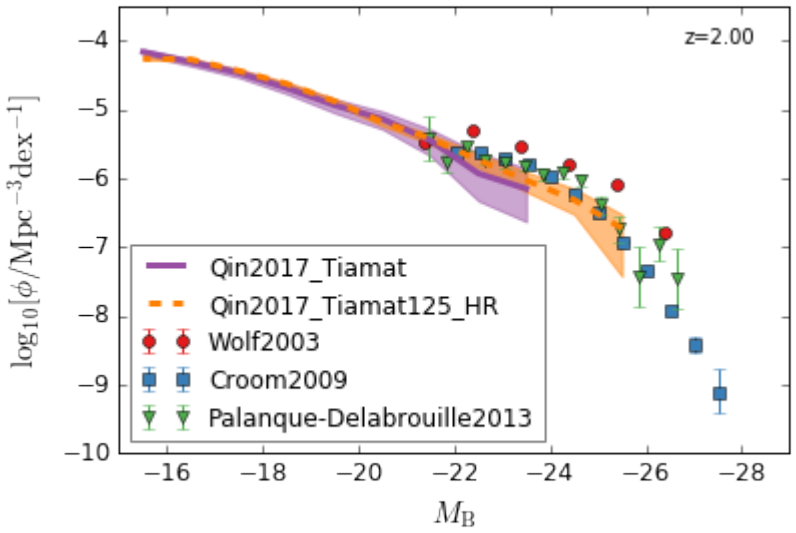
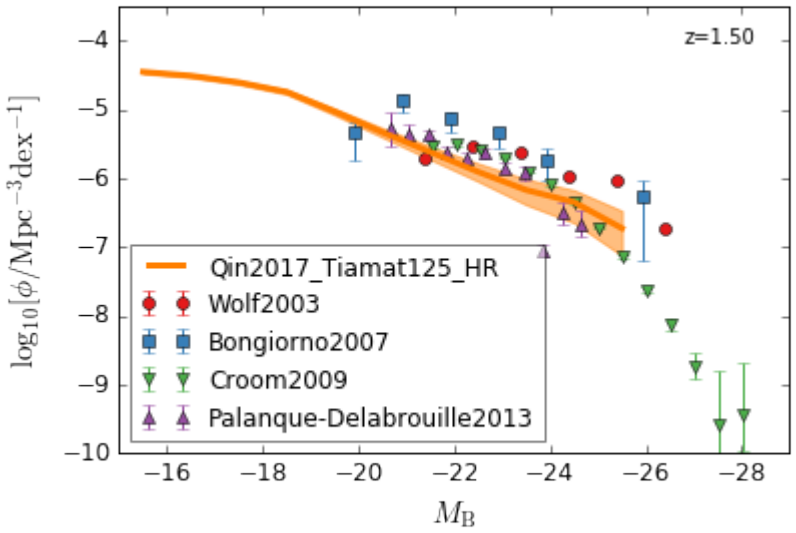
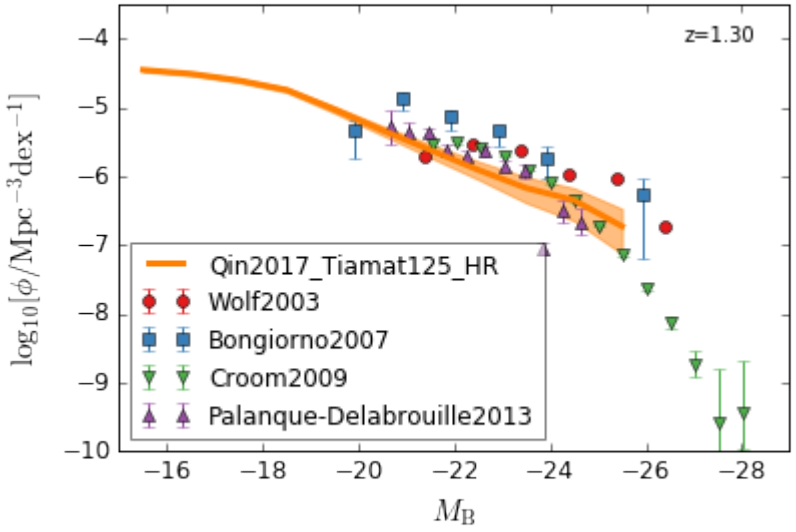
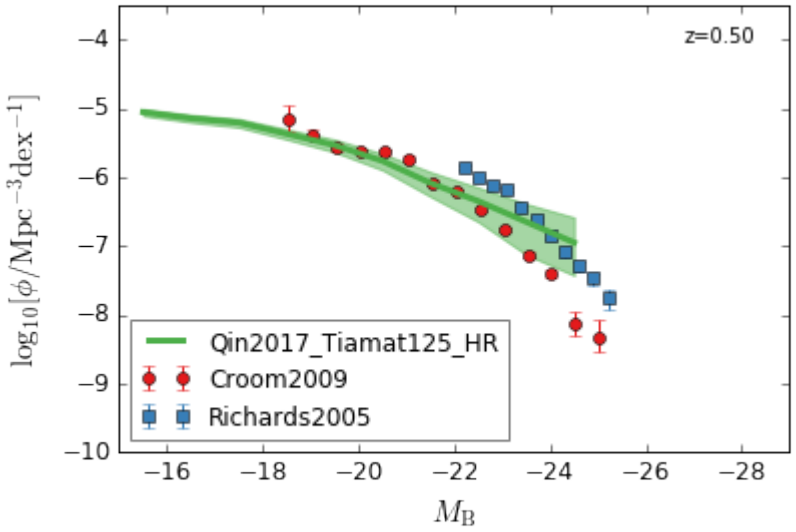
```
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```



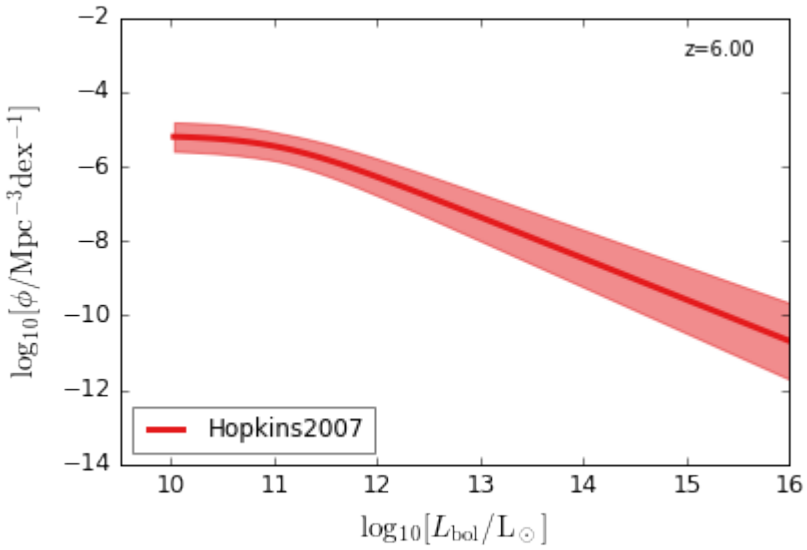

z=1.50
Qin2017_Tiamat125_HR
Wolf2003
Bongiorno2007
Croom2009
Palanque-Delabrouille2013
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_B

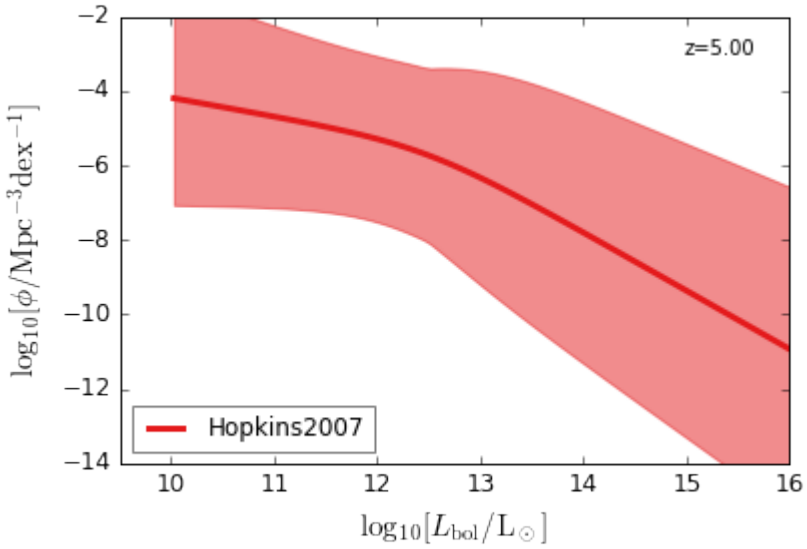

z=1.30
Qin2017_Tiamat125_HR
Wolf2003
Bongiorno2007
Croom2009
Palanque-Delabrouille2013
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_B

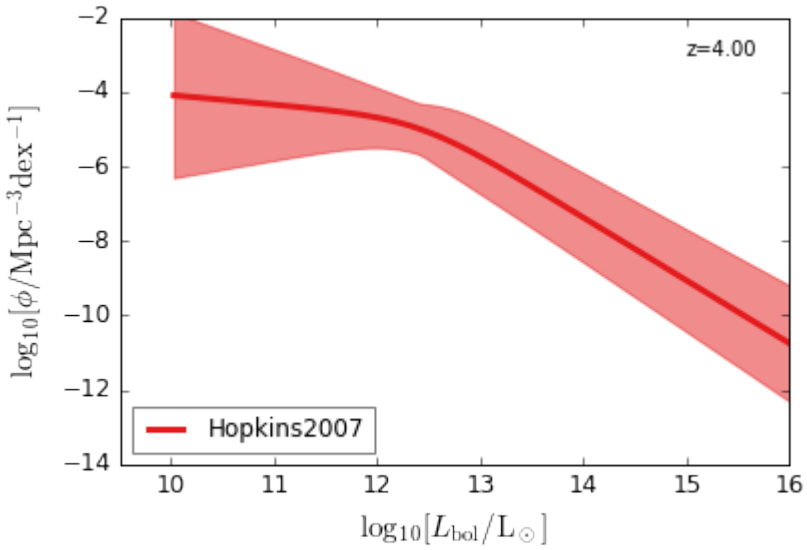

z=0.50
Qin2017_Tiamat125_HR
Croom2009
Richards2005
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
M_B

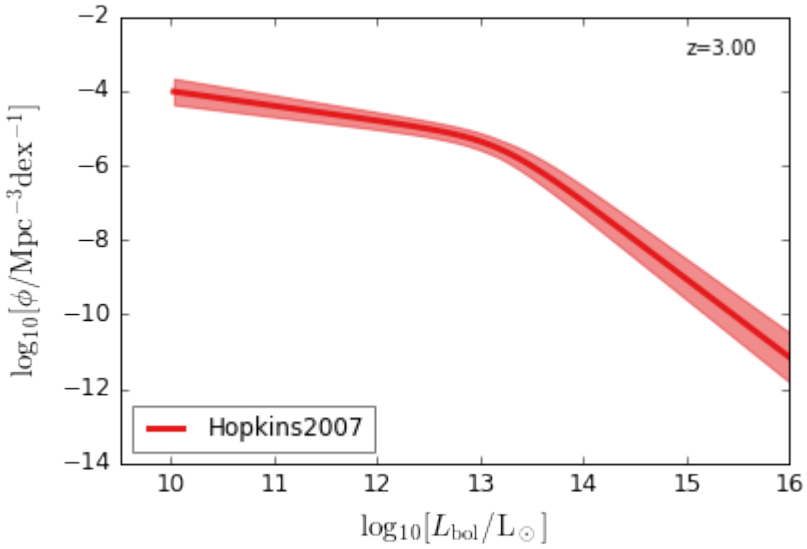
8.5.3 Bolometric

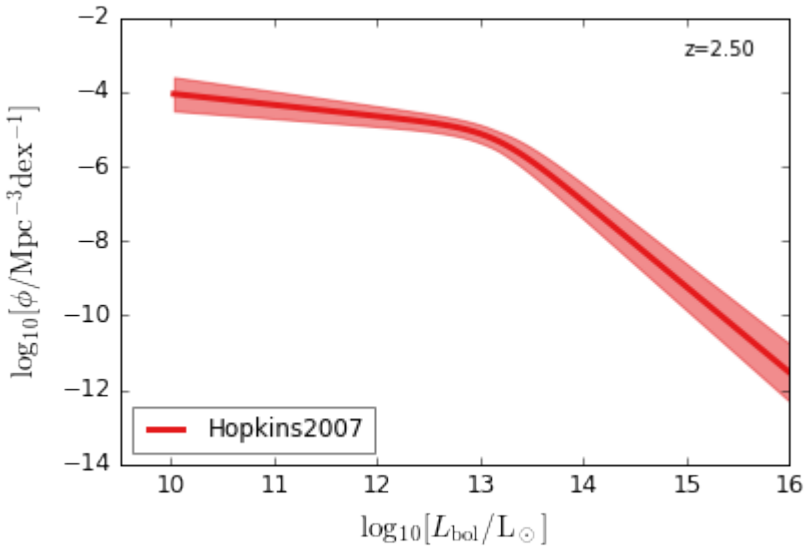
[15]:
```
feature = 'QLF_bolometric'
xlim    = (9.5, 16)
ylim    = (-14, -2)
xlabel  = r"$\log_{10}[L_{\rm bol}/{\rm L_\odot}]$"
ylabel  = r"$\log_{10}[\rm \phi/Mpc^{-3} dex^{-1}]$"
zs      = [6.0, 5.0, 4.0, 3.0, 2.5, 2.0, 1.5, 1.0, 0.5, 0.1]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = number_density(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data[:,1:] = np.log10(data[:,1:])
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

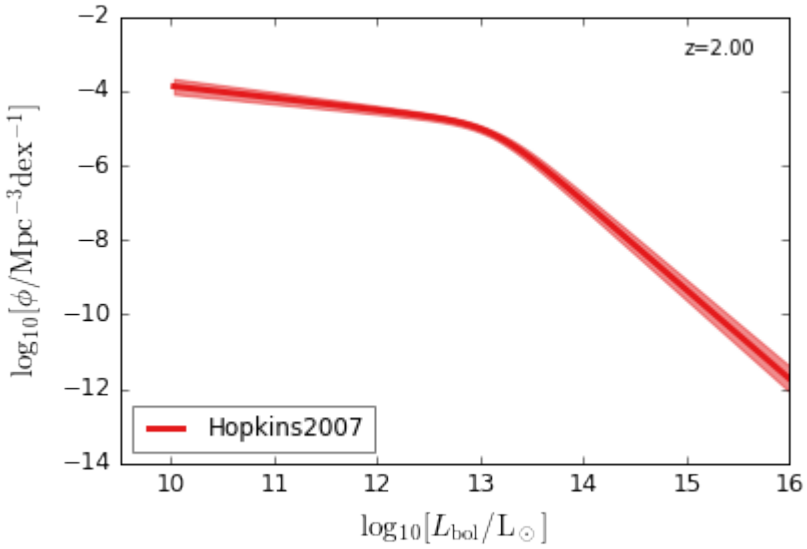

z=6.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16

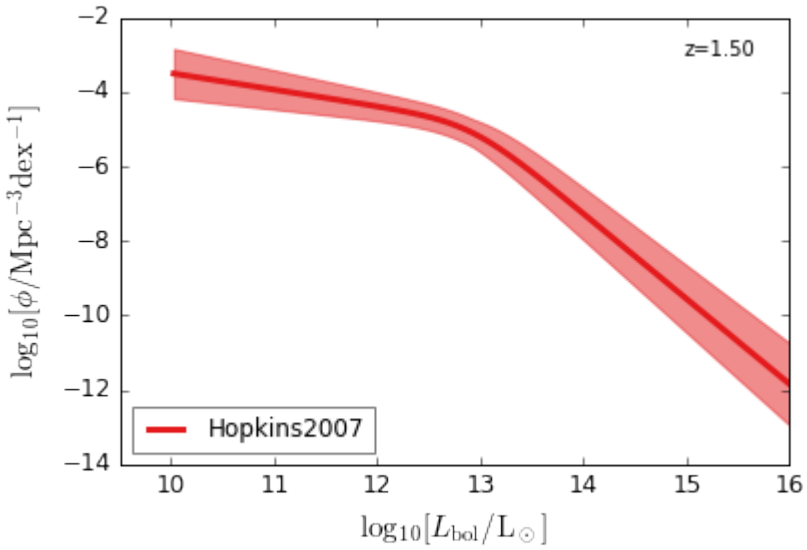

z=5.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16

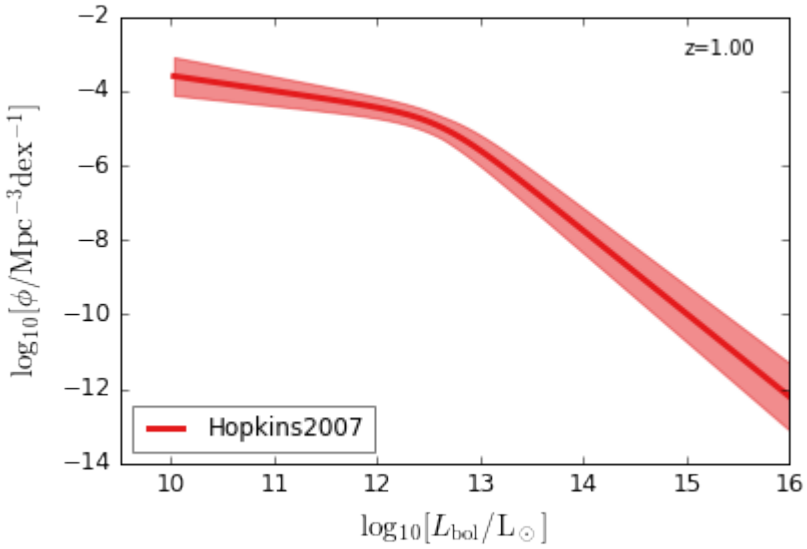

z=4.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16

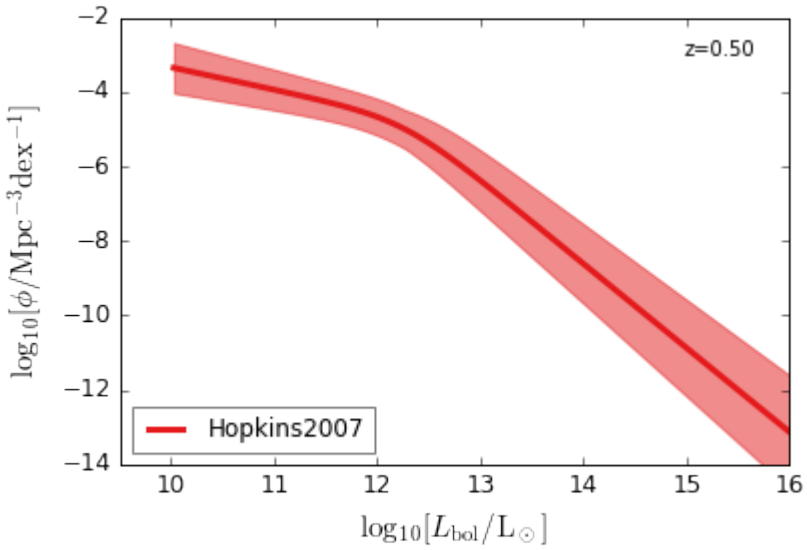

z=3.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16

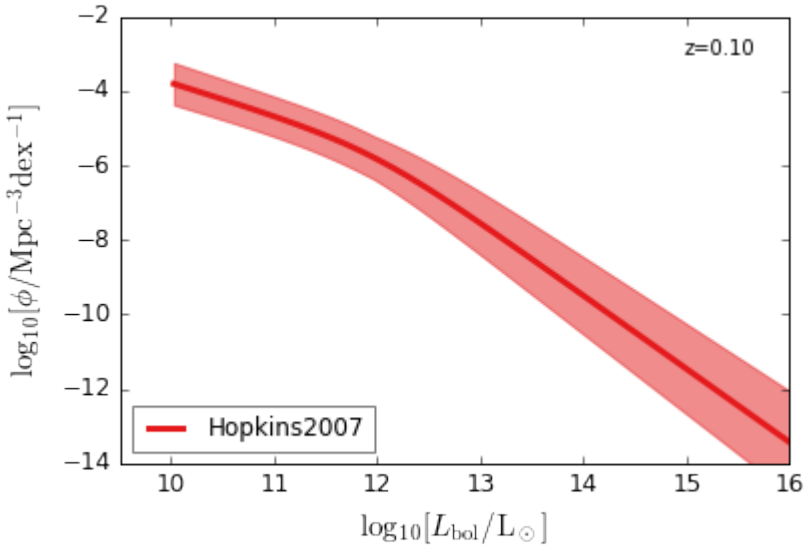

z=2.50
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16


z=2.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16


z=1.50
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16


z=1.00
Hopkins2007
$\log_{10}[\phi/\mathrm{Mpc}^{-3}\mathrm{dex}^{-1}]$
$\log_{10}[L_{\mathrm{bol}}/\mathrm{L}_{\odot}]$
−2
−4
−6
−8
−10
−12
−14
10
11
12
13
14
15
16





8.6 Magorrian Relation

[16]:
```
feature = 'Magorrian'
xlim   = (5, 13)
ylim   = (3, 11)
xlabel  = r"$\log_{10}[M_{\rm sph}/{\rm M_\odot}]$"
ylabel  = r"$\log_{10}[M_{\rm bh}/{\rm M_\odot}]$"
zs      = [0.0, ]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    for ii in range(obs.n_target_observation):
```

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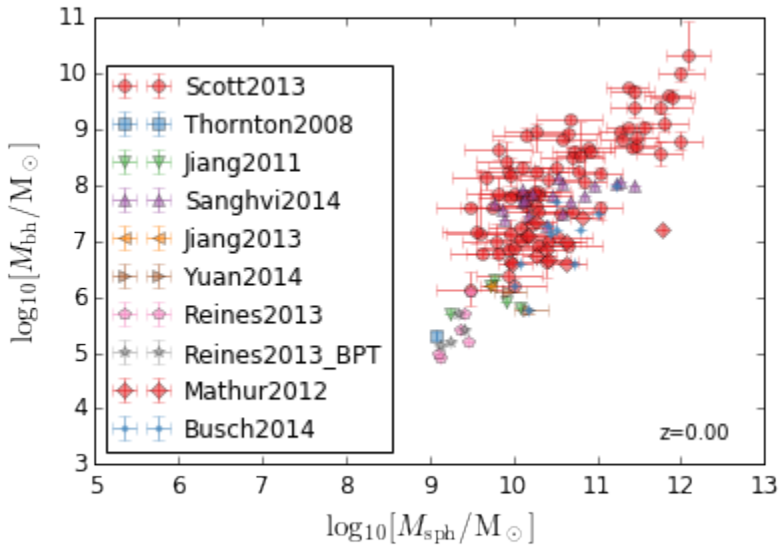
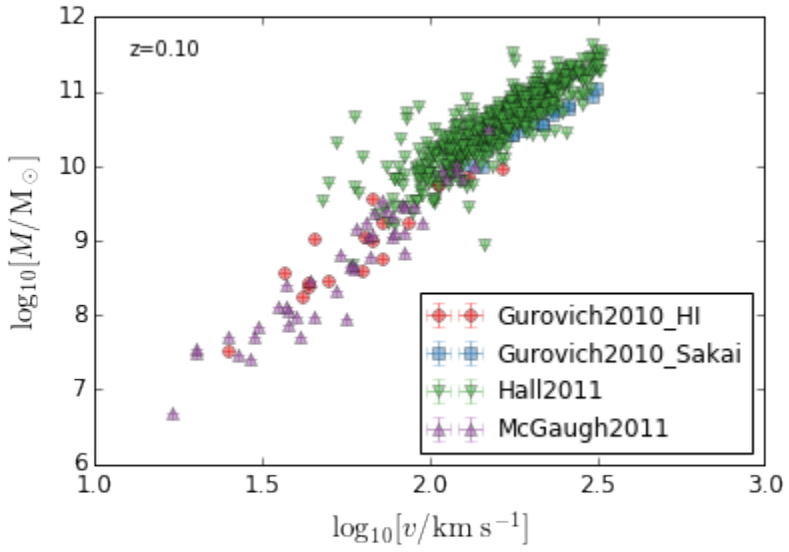
```
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[ii]
        linestyle  = linestyles[ii]
        data       = np.log10(data)
        if len(data)> 1e3:
            ax.hist2d(data[:,0], data[:,3],\
                      range = [xlim, ylim], bins=50,\
                      norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
            ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                      verticalalignment='bottom',transform=ax.transAxes)
        else:
            ax.errorbar(data[:,0],  data[:,3],\
                        xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.05, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='bottom',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```



8.7 Tully_Fisher Relation

[17]:
```
feature = 'Tully_Fisher'
xlim   = (1, 3)
ylim   = (6, 12)
xlabel  = r"$\log_{10}[v/{\rm km\ s^{-1}}]$"
ylabel  = r"$\log_{10}[M/{\rm M_\odot}]$"
zs      = [0.1, ]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[ii]
        linestyle  = linestyles[ii]
        data       = np.log10(data)
        if len(data)> 1e3:
            ax.hist2d(data[:,0], data[:,3],\
                      range = [xlim, ylim], bins=50,\
                      norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
            ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                      verticalalignment='bottom',transform=ax.transAxes)
        else:
            ax.errorbar(data[:,0],  data[:,3],\
                        xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.05,0.95, "z=%.2f"%z,horizontalalignment='left',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower right')
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```



8.8 DiskSize_StellarMass

[18]:
```
feature = 'DiskSize_StellarMass'
xlim   = (5, 13)
ylim   = (-2, 3)
xlabel  = r'$\log_{10}[M_{\rm disk}/{\rm M_\odot}]$'
ylabel  = r"$\log_{10}[R_{\rm disk}/{\rm kpc}]$"
zs      = [0.1, 0.35, 0.65, 0.95, 1.35, 1.75, 2.25, 2.75, 3.5]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[ii]
        linestyle  = linestyles[ii]
        data       = np.log10(data)
        if len(data)> 1e3:
            ax.hist2d(data[:,0], data[:,3],\
                      range = [xlim, ylim], bins=50,\
                      norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
            ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                      verticalalignment='bottom',transform=ax.transAxes)
        else:
            ax.errorbar(data[:,0],  data[:,3],\
                        xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
```

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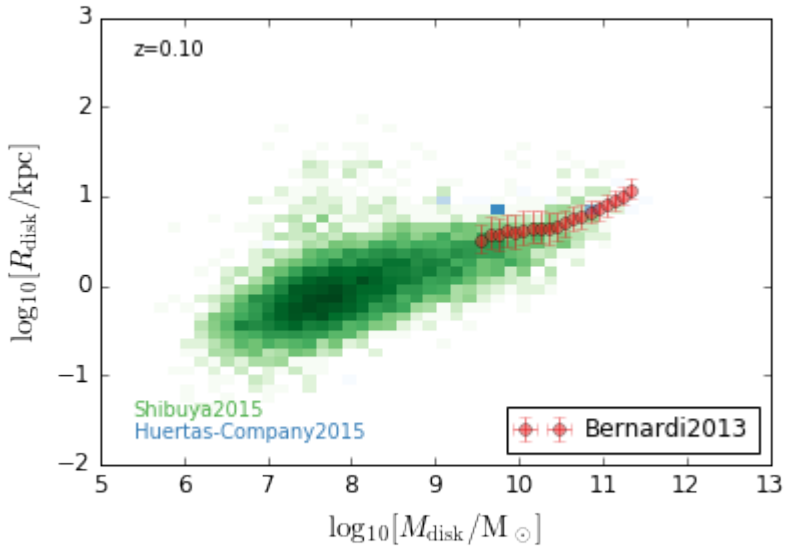
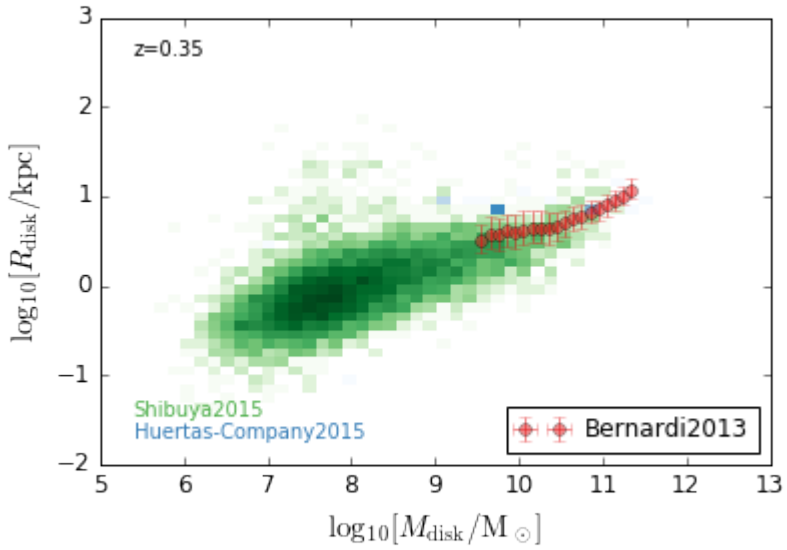
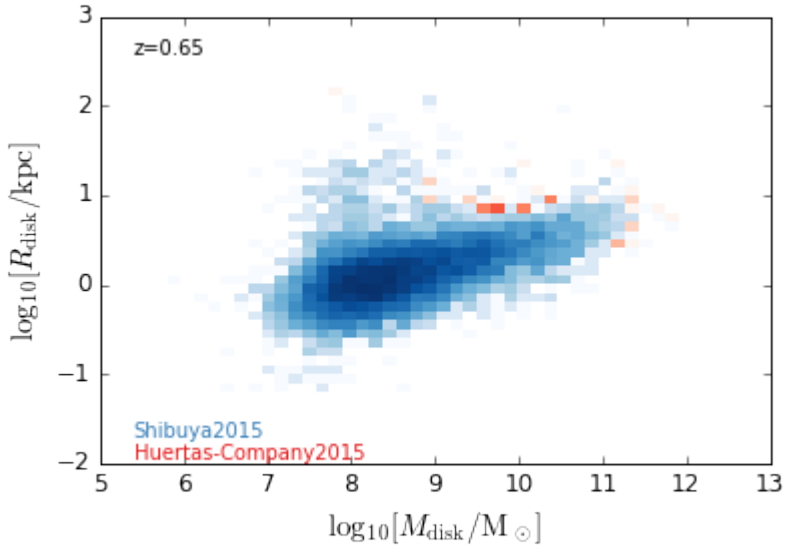
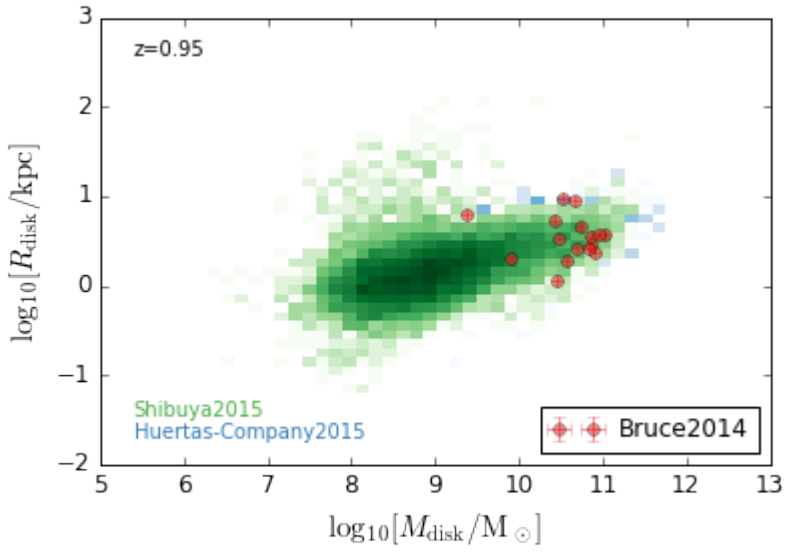
```
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.05,0.95, "z=%.2f"%z,horizontalalignment='left',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower right')
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

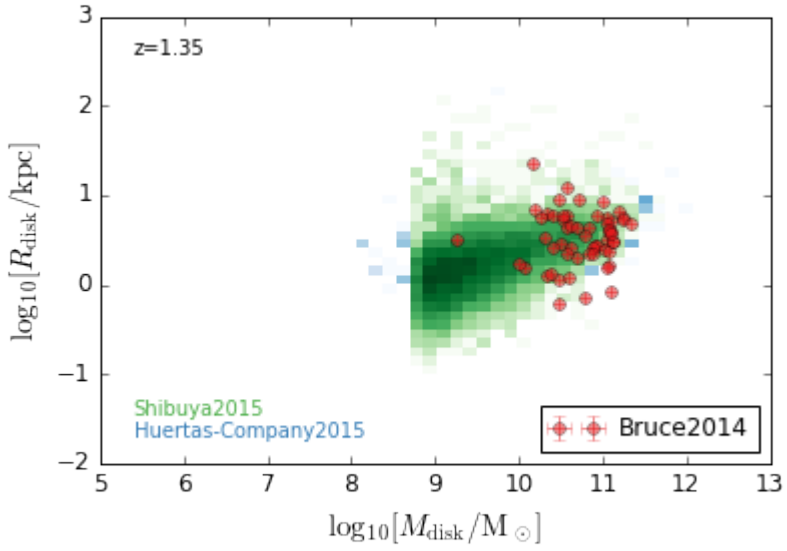
```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:18: RuntimeWarning:␣
↪divide by zero encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:18: RuntimeWarning:␣
↪invalid value encountered in log10
/home/yqin/3rd_party/lib/python3.6/site-packages/matplotlib/axes/_axes.py:531: UserWarning:␣
↪No labelled objects found. Use label='...' kwarg on individual plots.
  warnings.warn("No labelled objects found. "
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:23: RuntimeWarning:␣
↪invalid value encountered in subtract
```

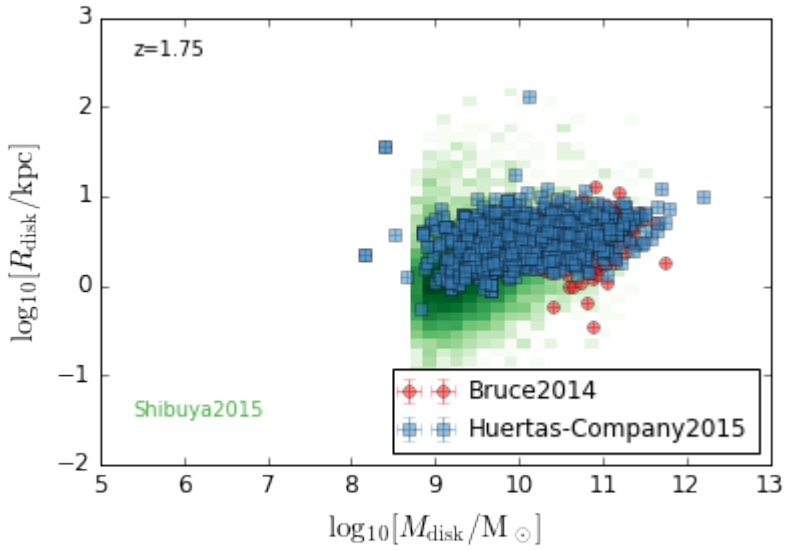


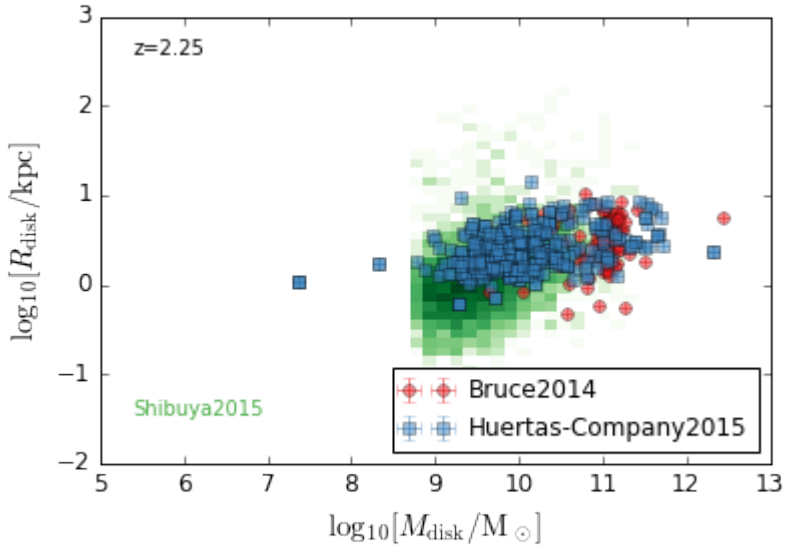

z=0.35
Shibuya2015
Huertas-Company2015
Bernardi2013
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$

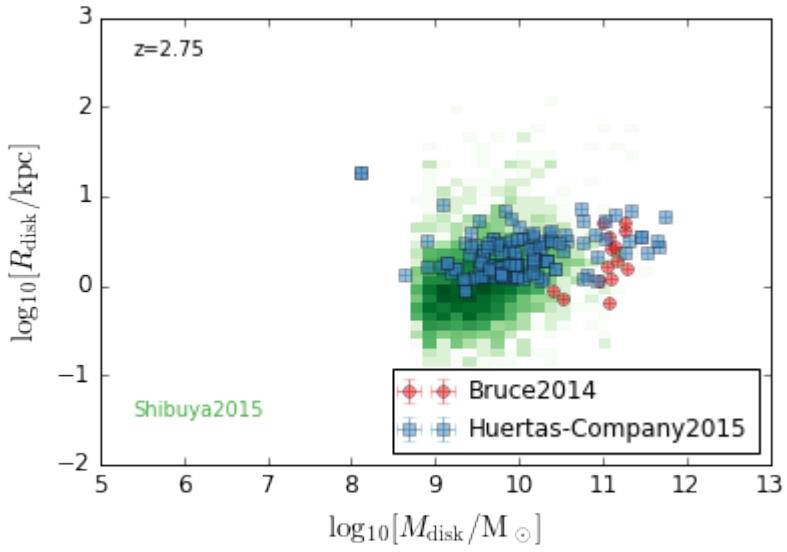

z=0.65
Shibuya2015
Huertas-Company2015
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$

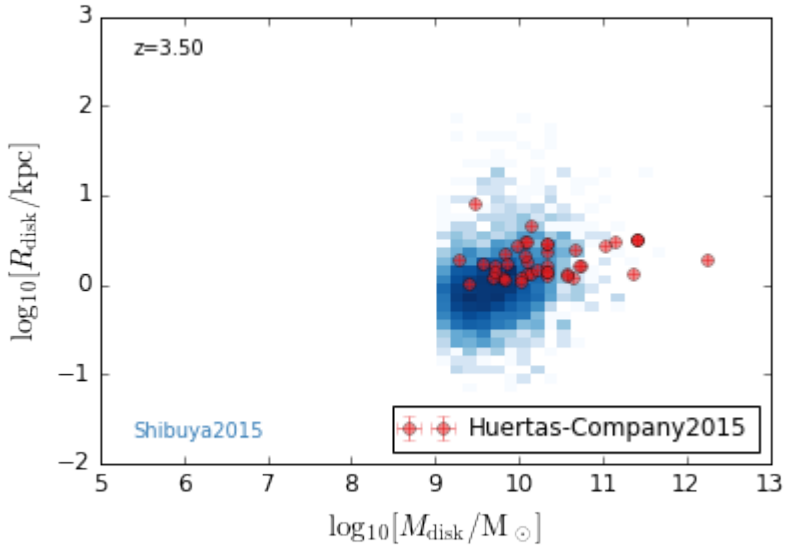

z=0.95
Shibuya2015
Huertas-Company2015
Bruce2014
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$


z=1.35
Shibuya2015
Huertas-Company2015
Bruce2014
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$


z=1.75
Shibuya2015
Bruce2014
Huertas-Company2015
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$


z=2.25
Shibuya2015
Bruce2014
Huertas-Company2015
$\log_{10}[R_{\rm disk}/{\rm kpc}]$
$\log_{10}[M_{\rm disk}/{\rm M}_\odot]$





8.9 GasFraction_StellarMass

[19]:
```
feature = 'GasFraction_StellarMass'
xlim   = (5, 13)
ylim   = (-2,3)
xlabel  = r'$\log_{10}[M_*/{\rm M_\odot}]$'
ylabel  = r"$\log_{10}[M_{\rm gas}/M_*]$"
zs      = [0.1,]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    for ii in range(obs.n_target_observation):
```

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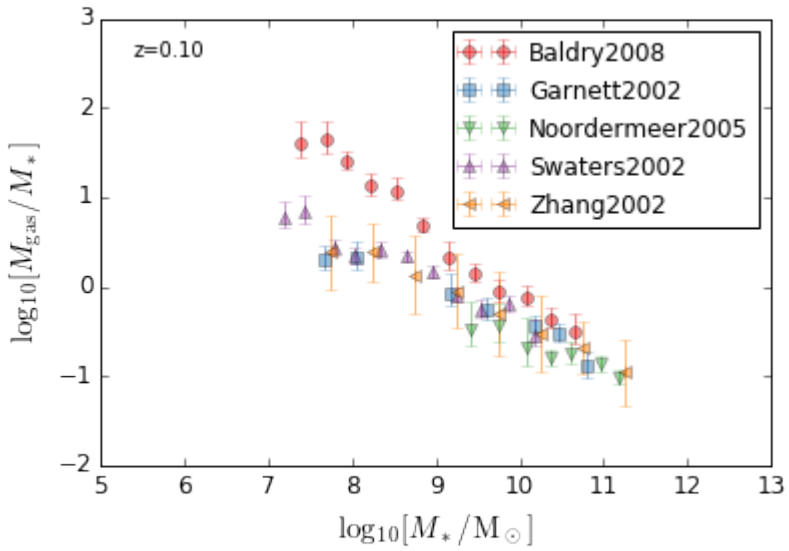
```
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[ii]
        linestyle  = linestyles[ii]
        data       = np.log10(data)
        if len(data)> 1e3:
            ax.hist2d(data[:,0], data[:,3],\
                      range = [xlim, ylim], bins=50,\
                      norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
            ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                      verticalalignment='bottom',transform=ax.transAxes)
        else:
            ax.errorbar(data[:,0],  data[:,3],\
                        xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.05,0.95, "z=%.2f"%z,horizontalalignment='left',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='upper right')
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

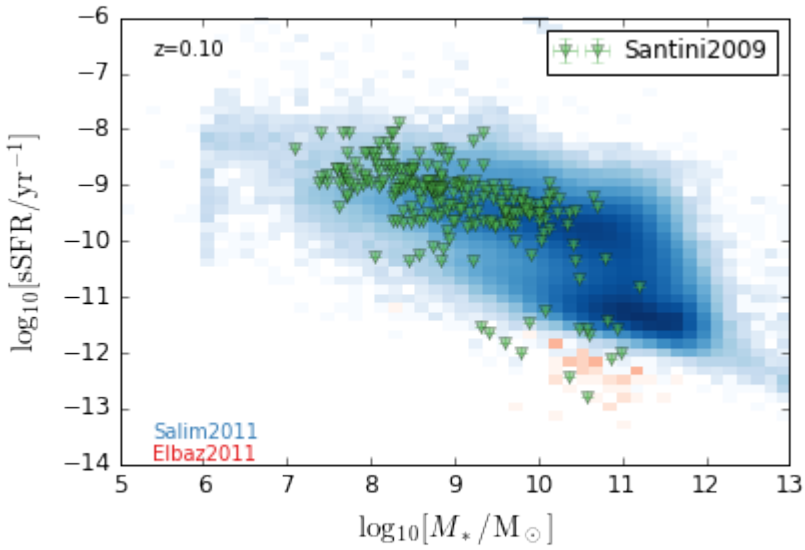


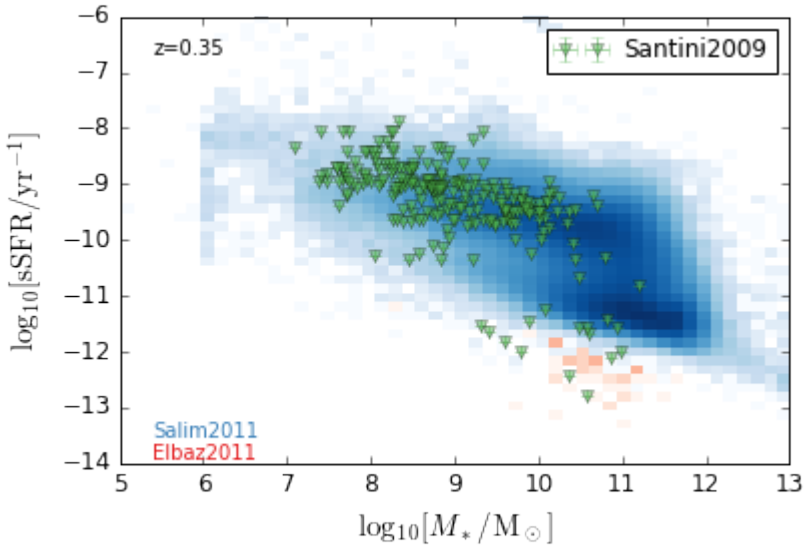
8.10 sSFR_StellarMass

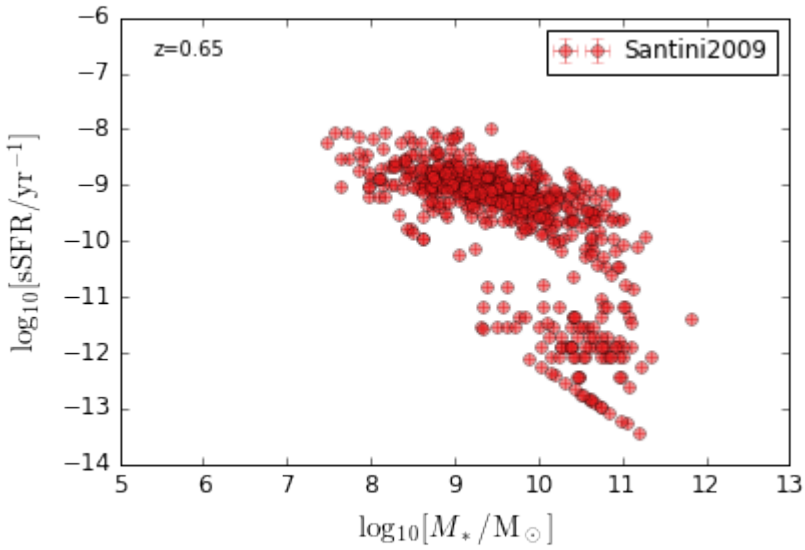
8.10.1 Blue

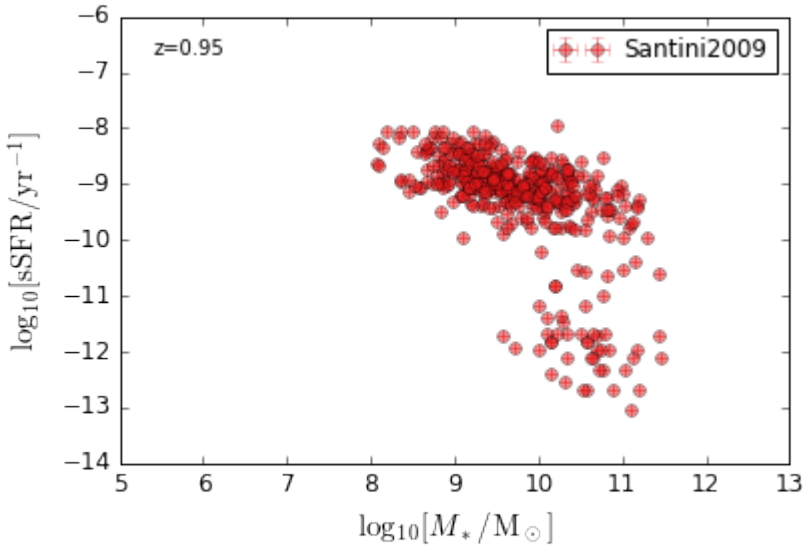
[20]:
```
feature = 'sSFR_StellarMass_Blue'
xlim   = (5, 13)
ylim   = (-14, -6)
xlabel  = r'$\log_{10}[M_*/{\rm M_\odot}]$'
ylabel  = r"$\log_{10}[{\rm sSFR/yr^{-1}}]$"
zs      = [0.1, 0.35, 0.65, 0.95, 1.35, 1.75, 2.25, 2.75, 3.5]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
        marker     = markers[ii]
        linestyle  = linestyles[ii]
        data       = np.log10(data)
        if len(data)> 1e3:
            ax.hist2d(data[:,0], data[:,3],\
                      range = [xlim, ylim], bins=50,\
                      norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
            ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                      verticalalignment='bottom',transform=ax.transAxes)
        else:
            ax.errorbar(data[:,0],  data[:,3],\
                        xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.05,0.95, "z=%.2f"%z,horizontalalignment='left',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='upper right')
    ax.set_xlabel(xlabel,fontsize=15)
    ax.set_ylabel(ylabel,fontsize=15)
```

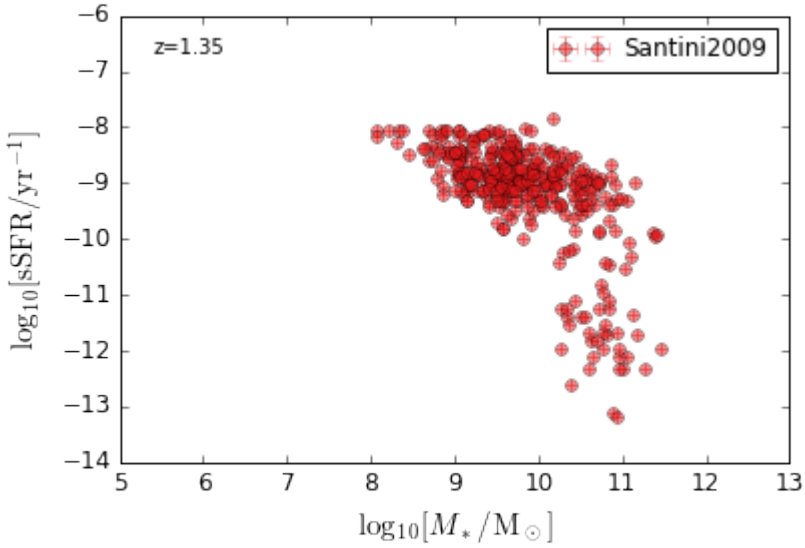
```
/home/yqin/3rd_party/lib/python3.6/site-packages/astrodatapy-0.0.dev23-py3.6.egg/astrodatapy/
↪correlation.py:480: RuntimeWarning: overflow encountered in power
  data = 10**data
```

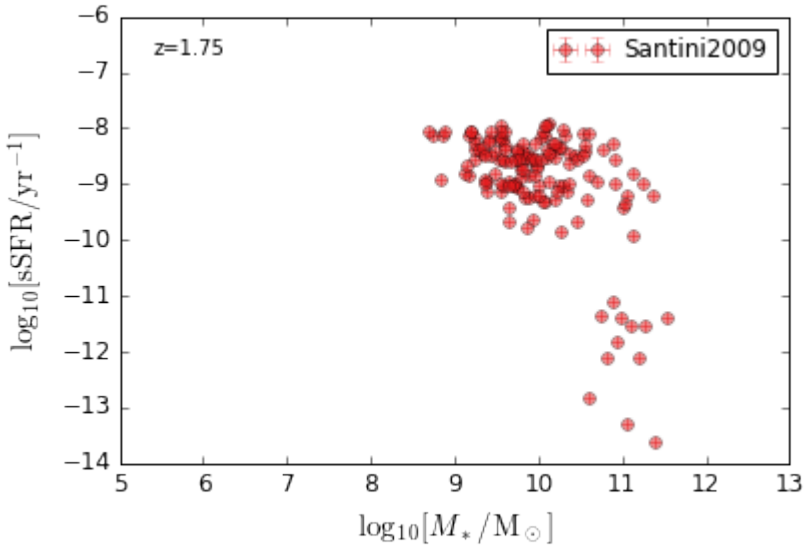

z=0.10
Santini2009
Salim2011
Elbaz2011
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$
−6
−7
−8
−9
−10
−11
−12
−13
−14
5
6
7
8
9
10
11
12
13

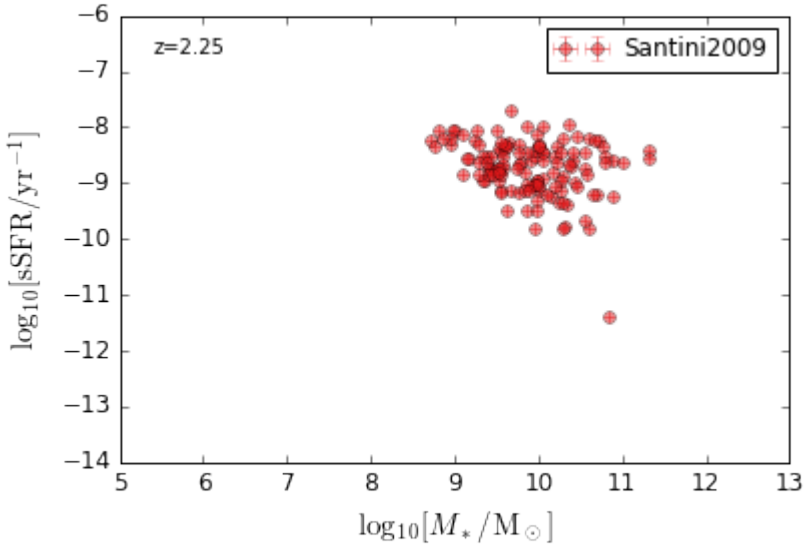

z=0.35
Santini2009
Salim2011
Elbaz2011
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$
−6
−7
−8
−9
−10
−11
−12
−13
−14
5
6
7
8
9
10
11
12
13

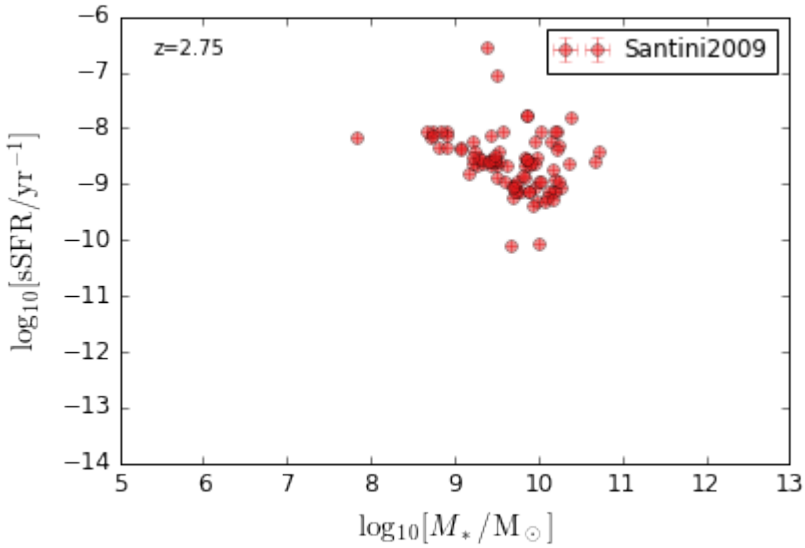

z=0.65
Santini2009
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$

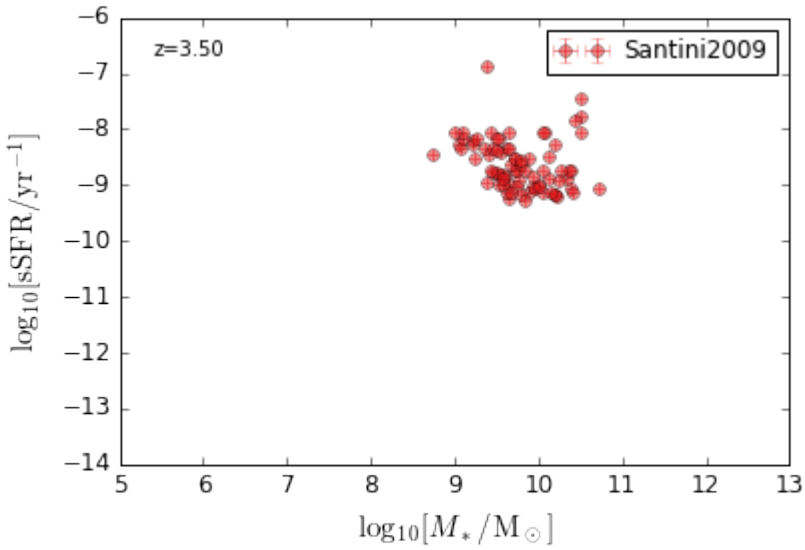

z=0.95
Santini2009
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=1.35
Santini2009
$\log_{10}[\mathrm{sSFR/yr^{-1}}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=1.75
Santini2009
$\log_{10}[\mathrm{sSFR/yr^{-1}}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$


z=2.25
Santini2009
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$
−6
−7
−8
−9
−10
−11
−12
−13
−14
5
6
7
8
9
10
11
12
13


z=2.75
Santini2009
$\log_{10}[\mathrm{sSFR}/\mathrm{yr}^{-1}]$
$\log_{10}[M_*/\mathrm{M}_\odot]$
−6
−7
−8
−9
−10
−11
−12
−13
−14
5
6
7
8
9
10
11
12
13



8.11 HaloMass_StellarMass

8.11.1 all & Blue & Red

[21]:
```
features = ['HaloMass_StellarMass', 'HaloMass_StellarMass_Blue', 'HaloMass_StellarMass_Red']
xlim     = (9, 12)
ylim     = (11, 14)
xlabel   = r'$\log_{10}[M_*/{\rm M_\odot}]$'
ylabel   = r"$\log_{10}[M_{\rm vir}/{\rm M_\odot}]$"
zs       = [0.1,]

for z in zs:
    fig,ax = plt.subplots(1,1)
    for feature, color  in zip(features, ['black', 'blue', 'red']):
        obs    = correlation(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
        for ii in range(obs.n_target_observation):
            data       = obs.target_observation['Data'][ii]
            label      = obs.target_observation.index[ii]
            datatype   = obs.target_observation['DataType'][ii]
            marker     = markers[ii]
            linestyle  = linestyles[ii]
            data       = np.log10(data)
            if len(data)> 1e3:
                ax.hist2d(data[:,0], data[:,3],\
                          range = [xlim, ylim], bins=50,\
                          norm=LogNorm(), label=label, cmap=plt.get_cmap(color_maps[ii]))
                ax.text(0.05,0.05*ii, label,horizontalalignment='left',color=color,\
                          verticalalignment='bottom',transform=ax.transAxes)
            else:
                ax.errorbar(data[:,0],  data[:,3],\
                            xerr = [data[:,1]-data[:,0], data[:,0] - data[:,2]],\
```

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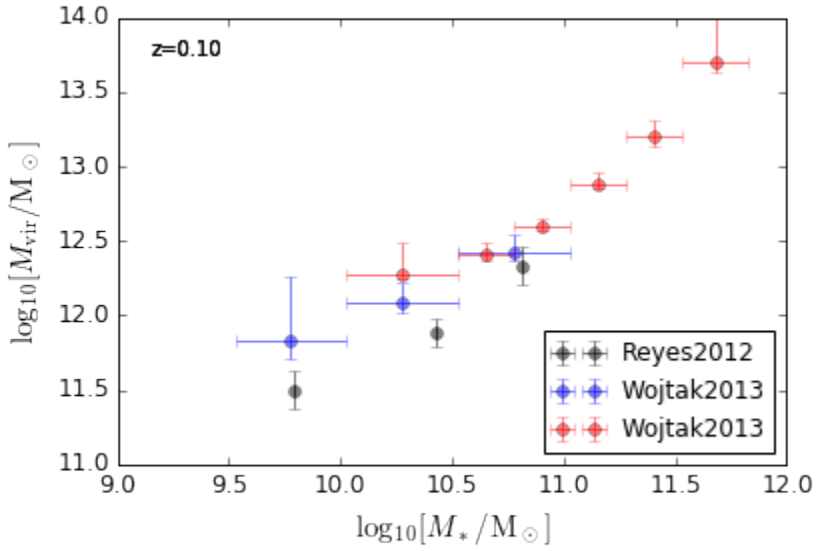
```
                        yerr = [data[:,4]-data[:,3], data[:,3] - data[:,5]],\
                        label=label,color=color,fmt=marker,alpha=0.5)
        ax.set_xlim(xlim)
        ax.set_ylim(ylim)
        ax.text(0.05,0.95, "z=%.2f"%z,horizontalalignment='left',\
              verticalalignment='top',transform=ax.transAxes)
        leg = ax.legend(loc='lower right')
        ax.set_xlabel(xlabel)
        ax.set_ylabel(ylabel)
```



8.12 QC_2PTCF

Quasar Clustering 2 Point Correlaion Function

[22]:
```
feature = 'QC_2PTCF'
xlim    = (-1, 3)
ylim    = (-3, 5.1)
xlabel  = r"$\log_{10}[r/\mathrm{cMpc}]$"
ylabel  = r"$\log_{10}\xi(r)$"
zs      = [4.5, 3.8, 3.2, 2.5, 1.5, 0.6]

for z in zs:
    fig,ax = plt.subplots(1,1)
    obs    = clustering(feature=feature,z_target=z,quiet=1,h=cosmo['h'])
    j_data = 0
    k_func = 0
    for ii in range(obs.n_target_observation):
        data       = obs.target_observation['Data'][ii]
        label      = obs.target_observation.index[ii]
        datatype   = obs.target_observation['DataType'][ii]
        color      = colors[ii]
```

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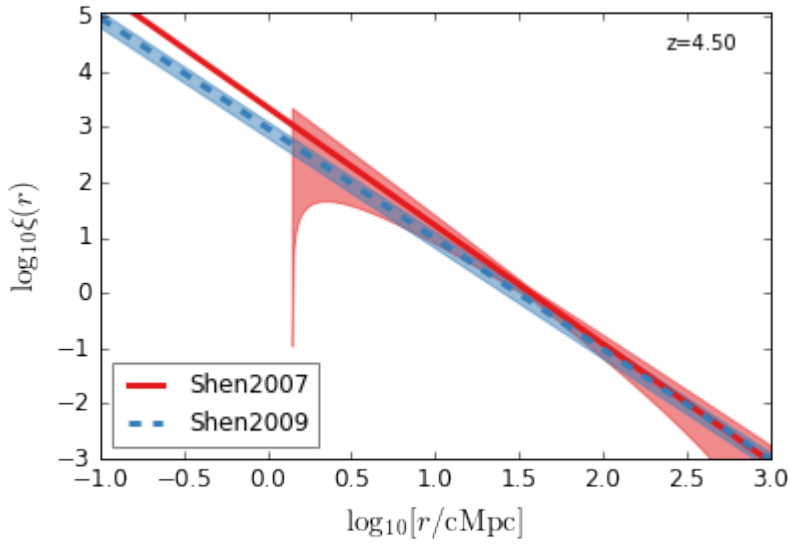
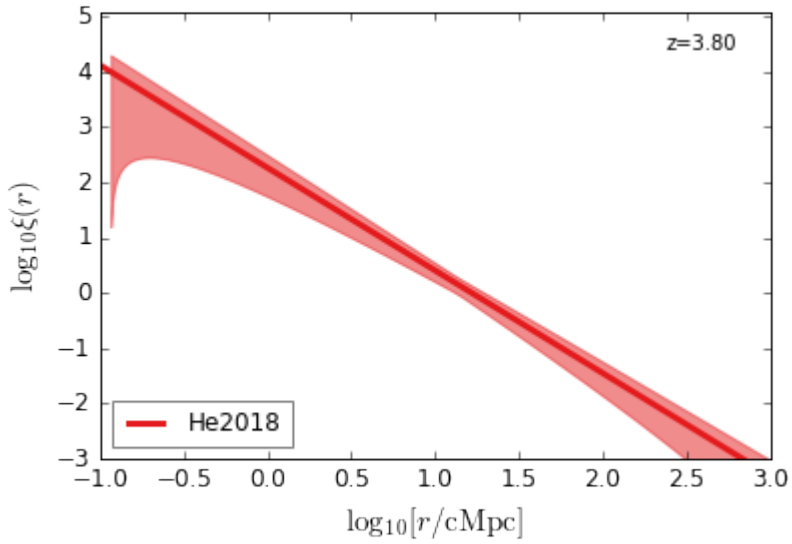
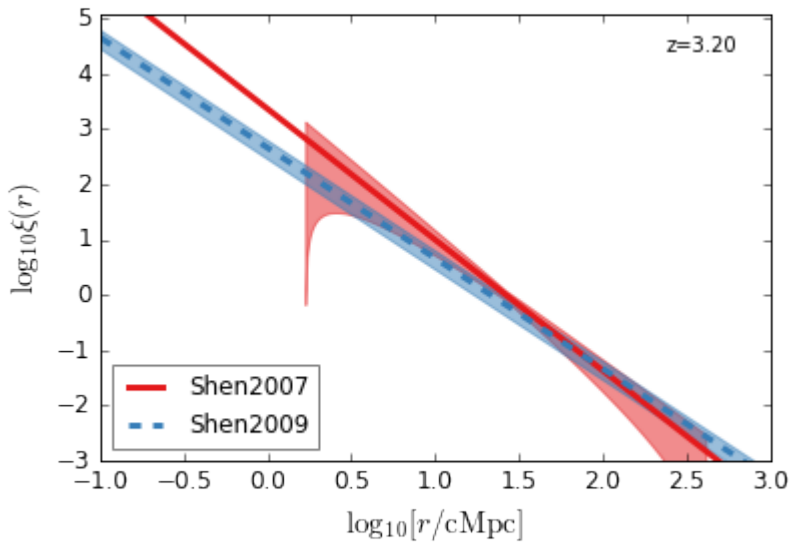
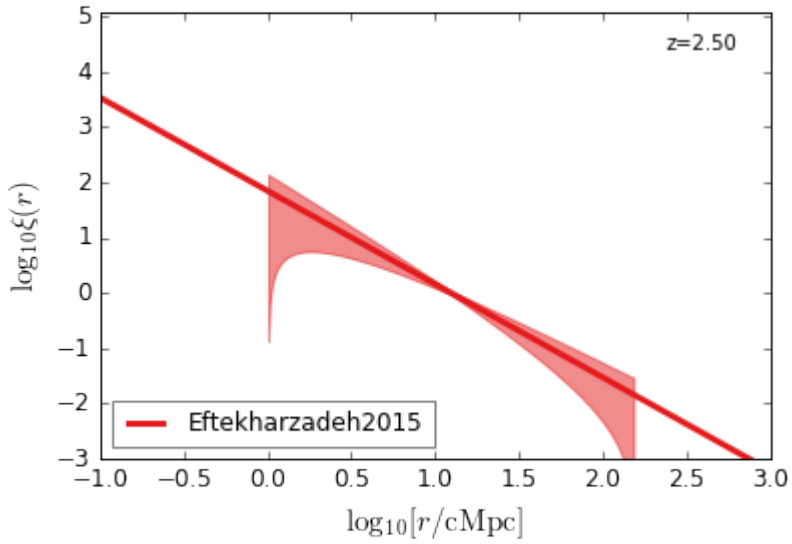
```
        marker     = markers[j_data]
        linestyle  = linestyles[k_func]
        data       = np.log10(data)
        if datatype == 'data':
            ax.errorbar(data[:,0],  data[:,1], yerr = [data[:,1]-data[:,3],data[:,2]- data[:,
↪1]],\
                        label=label,color=color,fmt=marker)
            j_data +=1
        elif datatype == 'dataULimit':
            ax.errorbar(data[:,0],  data[:,1], yerr = -0.2*data[:,1], uplims=True,\
                        label=label,color=color,fmt=marker)
            j_data +=1
        else:
            ax.plot(data[:,0],data[:,1],label=label,color=color,linestyle=linestyle,lw=3)
            ax.fill_between(data[:,0], data[:,2],data[:,3],color=color,alpha=0.5)
            k_func +=1

    ax.set_xlim(xlim)
    ax.set_ylim(ylim)
    ax.text(0.95,0.95, "z=%.2f"%z,horizontalalignment='right',\
          verticalalignment='top',transform=ax.transAxes)
    leg = ax.legend(loc='lower left')
    leg.get_frame().set_alpha(0.5)
    ax.set_xlabel(xlabel)
    ax.set_ylabel(ylabel)
```

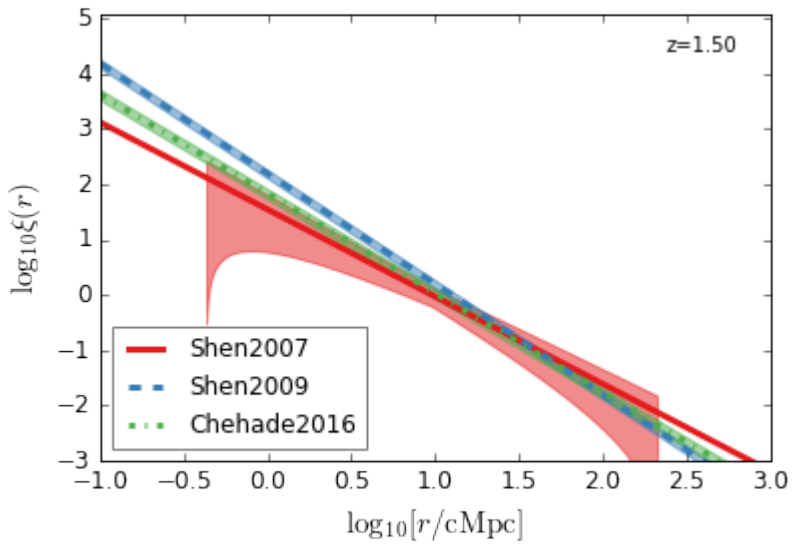
```
/home/yqin/3rd_party/lib/python3.6/site-packages/ipykernel_launcher.py:20: RuntimeWarning:␣
↪invalid value encountered in log10
```

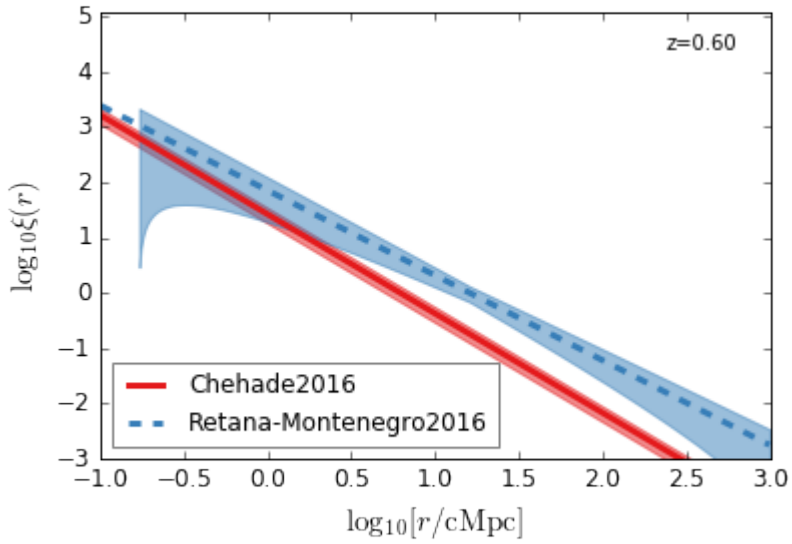



z=3.80
He2018
$\log_{10}\xi(r)$
$\log_{10}[r/\mathrm{cMpc}]$


z=3.20
Shen2007
Shen2009
$\log_{10}\xi(r)$
$\log_{10}[r/\mathrm{cMpc}]$


z=2.50
Eftekharzadeh2015
$\log_{10}\xi(r)$
$\log_{10}[r/\mathrm{cMpc}]$


z=1.50
Shen2007
Shen2009
Chehade2016
$\log_{10}\xi(r)$
$\log_{10}[r/\mathrm{cMpc}]$



[ ]:

Note: The layout of this directory is simply a suggestion. To follow traditional practice, do *not* edit this page, but instead place all documentation for the package inside `astrodatapy/`. You can follow this practice or choose your own layout.