vcirc_test-pymc3

February 20, 2018

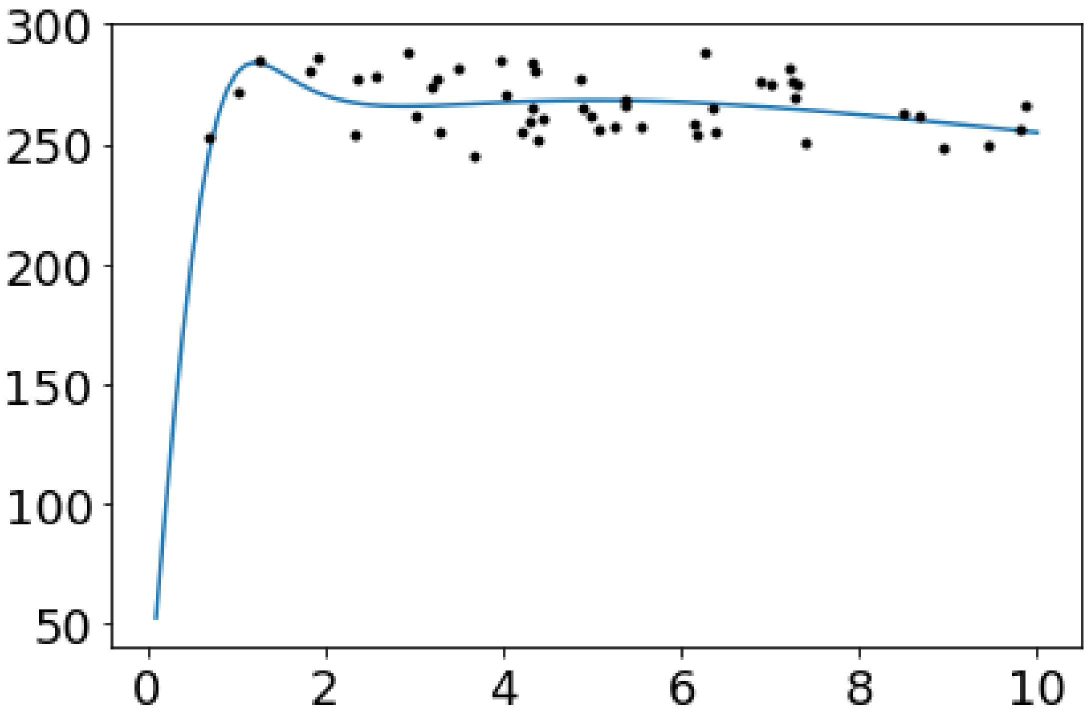
```
In [1]: import numpy as np
        import galpynamics
        import galpynamics.dynamic_component as dc
        import matplotlib.pyplot as plt
        from galpynamics.dynamics import galpotential
        from scipy import interpolate
        import warnings
        warnings.filterwarnings("ignore")
        import seaborn as sns
        from matplotlib.ticker import AutoMinorLocator
        from matplotlib import colors
        from matplotlib.colors import ListedColormap
        from matplotlib.ticker import AutoMinorLocator
        from matplotlib.ticker import MaxNLocator, MultipleLocator
        cm = 'plasma'
```

```
In [2]: #Generate some data
        def rot_curve(distance,Mbulge,Rbulge,Mdisc,Rdisc,Zdisc,Denshalo,Rhalo):
            halo=dc.NFW_halo(d0=Denshalo, rs=Rhalo, mcut=100., e=0.) #Halo
            bulge=dc.valy_halo(mass=Mbulge, rb=Rbulge, mcut=3., e=0.) #Bulge
            disc=dc.Exponential_disc.thick(sigma0=Mdisc/(2*np.pi*Rdisc**2.),Rd=Rdisc, zd=Zdisc,
            MW=galpotential(dynamic_components=(halo,disc,bulge))
            vgrid=MW.vcirc(distance,show_comp=True,nproc=1)
            return vgrid[:,-1]



        dist=np.linspace(0.1,10,100)
        np.random.seed(123)
        d_GC = np.random.uniform(0.1,10,50)
        v_rot = rot_curve(d_GC,2e10,0.5,5e10,2.5,0.3,3e7,10)
        v_obs = np.random.normal(v_rot,10) #dispersion around rotation curve

        plt.plot(dist, rot_curve(dist,2e10,0.5,5e10,2.5,0.3,3e7,10))
        plt.plot(d_GC, v_obs, 'k.')
        plt.show()
```



```
In [3]: #Working with theano variables
        import time
        import theano.tensor as tt
        from theano.compile.ops import as_op

        #####THEANO VERSION#####

        #Declaring function ready to work with theano variables using the decarator as_op to use
        @as_op(itypes=[tt.dvector,tt.dscalar,tt.dscalar,tt.dscalar,tt.dscalar,tt.dscalar,tt.dsca
        def rot_curve_theano(distance,Mbulge,Rbulge,Mdisc,Rdisc,Zdisc,Denshalo,Rhalo):
            halo=dc.NFW_halo(d0=Denshalo, rs=Rhalo, mcut=100., e=0.) #Halo
            bulge=dc.valy_halo(mass=Mbulge, rb=Rbulge, mcut=3., e=0.) #Bulge
            disc=dc.Exponential_disc.thick(sigma0=Mdisc/(2*np.pi*Rdisc**2.),Rd=Rdisc, zd=Zdisc,
            MW=galpotential(dynamic_components=(halo,disc,bulge))
            vgrid=MW.vcirc(distance,show_comp=True,nproc=1)
            return vgrid[:,-1]

        #Variables using _shared theano tensor to pass from pure python variables to theano tens
        distance=tt._shared(d_GC)
        Mbulge=tt._shared(np.cast['float64'](2.0e10))
        Rbulge=tt._shared(np.cast['float64'](0.5))
        Dhalo = tt._shared(np.cast['float64'](3e7))
        Rhalo = tt._shared(np.cast['float64'](10))
        Mdisc = tt._shared(np.cast['float64'](5e10))
```

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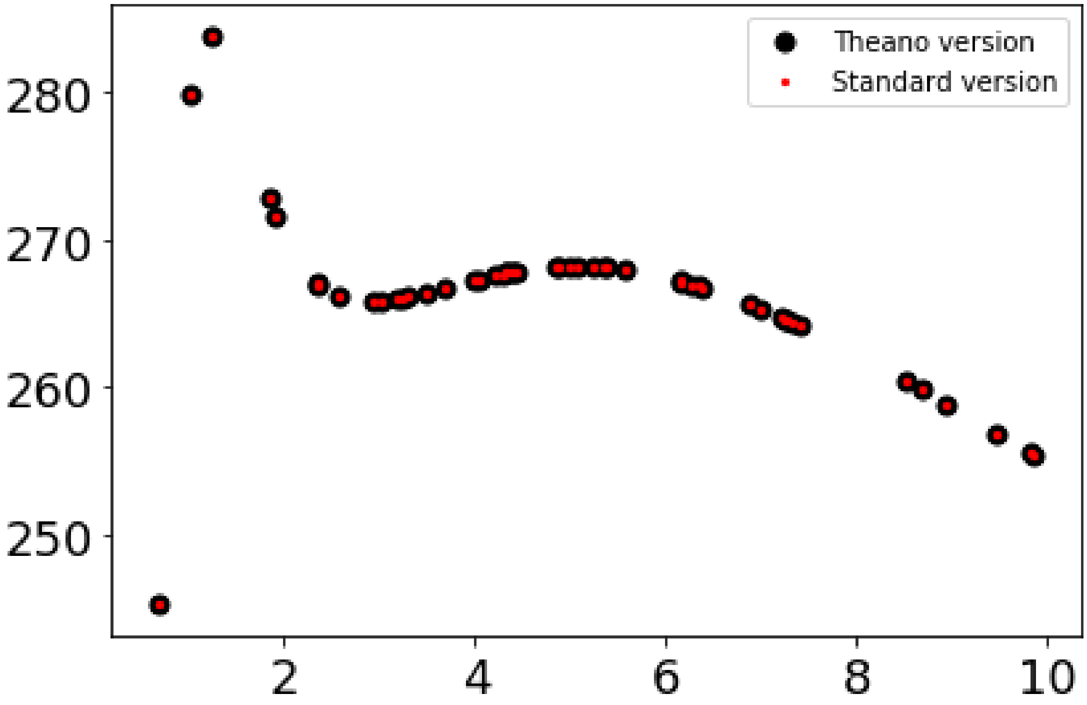
Rdisc = tt._shared(np.cast['float64'](2.5))
Zdisc = tt._shared(np.cast['float64'](0.3))

#timing
t1=time.time()
v_rot_theano = rot_curve_theano(distance,Mbulge,Rbulge,Mdisc,Rdisc,Zdisc,Dhalo,Rhalo)
t2a=time.time()
v_rot=v_rot_theano.eval()
t2b=time.time()
print('Theano version time (estimating vrot)',t2a-t1)
print('Theano version time (estimating vrot+cast to numpy array)',t2b-t1)


###STANDARD VERSION
#timing
t1=time.time()
v_rot = rot_curve(d_GC,2.0e10,0.5,5e10,2.5,0.3,3e7,10)
t2=time.time()
print('Standard version time (estimating vrot)',t2-t1)

#Comparative plot
plt.scatter(d_GC,v_rot,label='Theano version',c='black',s=50) #THEANO
plt.scatter(d_GC,v_rot,s=5,label='Standard version',c='red') #STANDARD
plt.legend()
plt.show()
```

```
Theano version time (estimating vrot) 0.003948211669921875
Theano version time (estimating vrot+cast to numpy array) 1.5795609951019287
Standard version time (estimating vrot) 1.5427241325378418
```



```
In [4]: #PYMC3#
        import pymc3 as pm
        import corner



        RC_model = pm.Model()
        with RC_model as model_deterministic:
            # Priors for unknown model parameters
            Dhalo = pm.Uniform('Dhalo', lower=1e+6,upper=1e+8)
            Rhalo = pm.Uniform('Rhalo', lower=1.,upper=50.)
            Mdisc = pm.Uniform('Mdisc', lower=1e+10,upper=1e+12) #pm.Normal('Mdisc', mu=1e+10, s
            Rdisc = pm.Normal('Rdisc', mu=2.5, sd=0.1)#pm.Uniform('Rdisc', lower=1.,upper=10.)
            Zdisc = pm.Normal('Zdisc', mu=0.3, sd=0.1)#pm.Uniform('Hdisc', lower=0.05,upper=0.5)

            #Constant parameters
            distance=tt._shared(d_GC)
            Mbulge=tt._shared(np.cast['float64'](2.0e10))
            Rbulge=tt._shared(np.cast['float64'](0.5))

            # Expected value of outcome (model)
            v_rot = rot_curve_theano(distance,Mbulge,Rbulge,Mdisc,Rdisc,Zdisc,Dhalo,Rhalo)

            # Likelihood (sampling distribution) of observations
```

```
    v_fit = pm.Normal('v_fit', mu=v_rot, sd=10, observed=v_obs)


with RC_model:

    #Number of threads
    nproc=4
    #Number of burn-in samples
    Nburn=10
    # Number of posterios samples
    Npost=10
    # instantiate sampler
    step = pm.Metropolis()
    # draw  posterior samples
    trace = pm.sample(draws=Npost,step=step,njobs=nproc,tune=Nburn)
```

```
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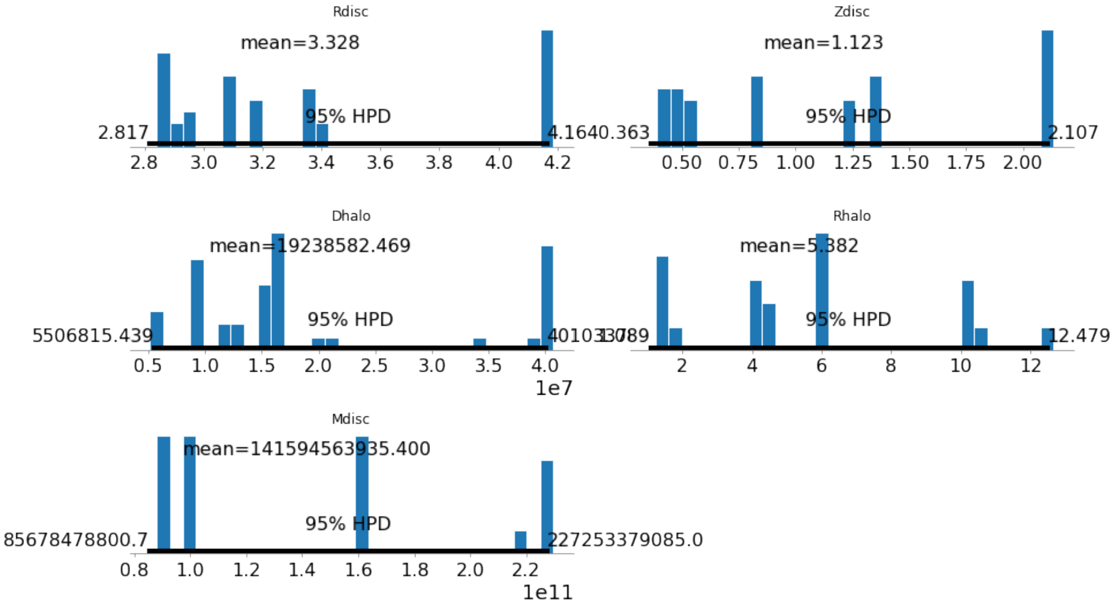
```

```
In [5]: pt=pm.plot_posterior(trace)
```


Rdisc
mean=3.328
95% HPD
Zdisc
mean=1.123
95% HPD
Dhalo
mean=19238582.469
95% HPD
1e7
Rhalo
mean=5.382
95% HPD
Mdisc
mean=141594563935.400
95% HPD
1e11