GW150914Simple

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1 The Equation 5 simple calculation of the order of magnitude of GW150914 using mass units (G=c=1).

```
In [1]: import numpy as np
```

1.1 Cycle 5 is at 0.35 seconds which is 2.5 orbits before "coalescence." And the centroid of the yellow band is close to 48 Hz for f_GW givin the orbital f_orb about 24 Hz.

And the Kepler relation for the average angular frequency of the orbit (elliptical or circular) is

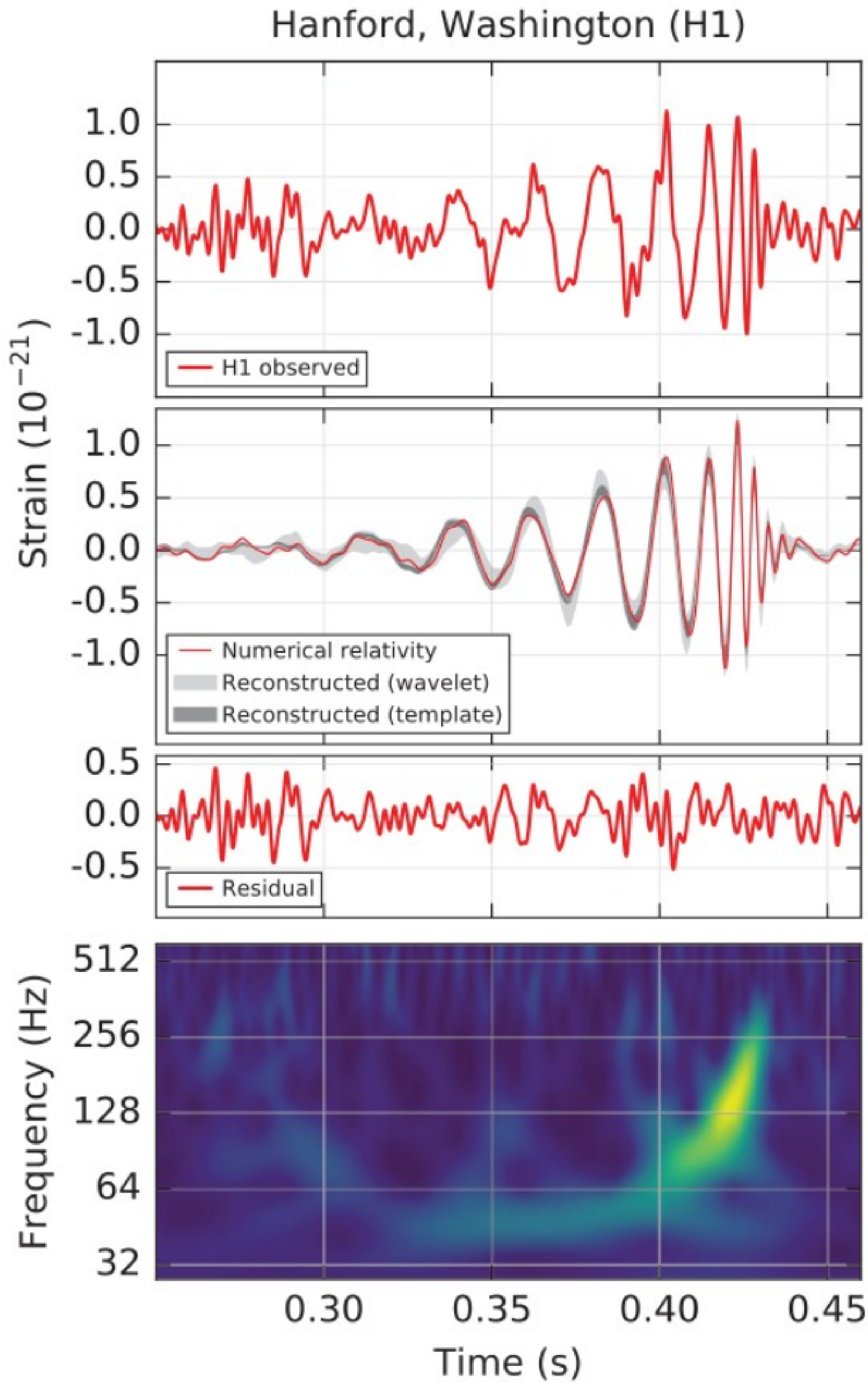
$$\omega_0^2 = \frac{G(m_1 + m_2)}{a^3}$$

```
In [2]: fGW = 48.0;
        f0 = fGW/2.0; # Orbital frequency
        omega0 = 2*np.pi*f0
        print(omega0)
```

```
150.79644737231007
```

```
In [3]: Lsol = 1477.71; # meters, G=c=1 units for 1 solar mass, half the Schwarzsch
        cee = 299792458.0; # m/s, speed-of-light in SI
        m1 = 36.0; # msol
        m2 = 29.0; # msol
        dist = 410.; # Mpc  1pc = 3.086e16 m = 3.262 ly
        distMsol = dist*1e6*3.086e16/Lsol
        print('Distance to binary in Msol units is ', distMsol)
```

```
Distance to binary in Msol units is  8.562302481542387e+21
```


Hanford, Washington (H1)
Strain (10^{-21})
1.0
0.5
0.0
-0.5
-1.0
H1 observed
Numerical relativity
Reconstructed (wavelet)
Reconstructed (template)
Residual
Frequency (Hz)
512
256
128
64
32
0.30
0.35
0.40
0.45
Time (s)

title

2 Find a from Kepler relation above. Units of Msol.

Use the relation for a in above, and liberal use of $L_\odot = GM_\odot/c^2 = 1477.71\mathrm{m}$ than

$$a^3 = L_\odot^3 \frac{(m_1+m_2)}{M_\odot} \frac{1}{L_\odot^2 \frac{\omega_0^2}{c^2}}$$

```
In [4]: # first dimensionless coefficient Mtot/Msol
        first = (m1+m2);
        # second is 1/ Lsol * omega^2/c^2
        second = 1/(Lsol*omega0/cee)**2;
        ameters = Lsol*(first*second)**(1/3)
        print('Mass separation in meters', ameters)
```

```
Mass separation in meters 724081.1665248007
```

```
In [5]: # In units of G=c=1, for a one solar mass "distance" that is 1 Lsol in mete
        aMsol = (first*second)**(1/3)
        print('Mass separation in Msols', aMsol)
```

```
Mass separation in Msols 490.0022105317015
```

Using the order of magnitude forumla from our paper (and others) that

$$h_0 = \frac{r_{s1} \cdot r_{s2}}{a \cdot r}$$

where r_{si} are the Schwarzschild radii, a is the mass separation, and r is the distance from the observer to the binary.

```
In [6]: hzero = (2*m1)*(2*m2)/( aMsol*distMsol)
        print('Estimate from GW freq of %4.1f that the h0 is %7.4g at earth.'%(fGW,
```

```
Estimate from GW freq of 48.0 that the h0 is 9.953e-22 at earth.
```

```
In [ ]:
```