Schnupp

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1 Schnupp asymmetry measurement

1.1 Time of flight meausurement

By measuring the flight time of photon to the ITMs, we can know the Schnupp asymmetry. The flight time difference corresponds to the difference of the optimal phase for the PDH signal in each arm.

The optimal demodulation phase for each arm, θ_x and θ_y, can be derived as

$$\theta_i = -\frac{(L_1+2L_i+L_2)}{c}\omega_m \quad (i=x,y),$$

where L_1 is distance from an EOM to the BS, L_i is distance from the BS to the ITMX(Y), and L_2 is distance from the BS to the PD. Therefore, the difference of the optimal demodulation phase $theta_d$ for each arm can be derived as

$$\theta_d = \theta_x - \theta_y = -\frac{2(L_x-L_y)}{c}\omega_m.$$

The Schnupp asymmetry L_d can be derived as

$$L_d = L_x - L_y = -\frac{\theta_d}{2\omega_m}c$$

```python
import numpy as np

# light speed
c = 3.e8

# design value
designed_L_d = 3.3

# modulation frequencies
seed = 5.63e6
omega = {'45':seed*8*2*np.pi,'17':seed*3*2*np.pi,'51':seed*9*2*np.pi,'135':
    seed*24*2*np.pi}

#measurement results
theta_x = {'REFL45':122.2, 'AS17':-36.43,'POP17':141.9,'POP45':208,'REFL51':205.
    4,'REFL135':-14.74}
theta_y = {'REFL45':121.2, 'AS17':101.0,'POP17':-80.8,'POP45':209.9,'REFL51':
    -105.0,'REFL135':-11.71}
```

```python
L_d = {}

# caluculate L_d
for PD in theta_x:
    theta_d = (np.deg2rad(theta_x[PD]-theta_y[PD]))

    regex = re.compile('\d+')
    freq = regex.findall(PD)[0]

    _L_d = -(theta_d-2*np.pi*np.array(range(10)))/(2*omega[freq])*c
    idx = np.abs(np.asarray(_L_d) - designed_L_d).argmin()
    L_d[PD] = _L_d[idx]

L_d_list = np.array([L_d[PD] for PD in L_d])




print('Measured schnup asymmetry')
print('------------------------')
print('average: %f m'%L_d_list.mean())
print('standard error:%f m'%(L_d_list.std()/np.sqrt(len(L_d_list))))
print('')
print('')
for PD in L_d:
    print('By %s: %f m'%(PD,L_d[PD]))
```

```
Measured schnup asymmetry
------------------------
average: 3.359070 m
standard error:0.010253 m


By REFL51: 3.368199 m
By REFL45: 3.321122 m
By REFL135: 3.339717 m
By POP17: 3.387113 m
By POP45: 3.347950 m
By AS17: 3.390320 m
```