Discussion on the proposed exercises

1. **VESF February 2010**

   On the pulsars analysis

   – **Pulsar number 6** Here the signal was added to ten days of simulated data. The simulated sensitivity is comparable to the average VSR2 sensitivity. The two gds with the signals 5-vectors have in this case to be read from the two .mat files located in the pulsar's directory. The noise+signal is always in the sbl file. This for simplicity. Thus substitute the commands used for the other pulsars, e.g.
     g=pss_band_recos1(pulsar_3s(),'sim6_p3s.sbl',1024);
     g0=pss_band_recos1(pulsar_3s(),'s0_p3s.sbl',1024);
     g45=pss_band_recos1(pulsar_3s(),'s45_p3s.sbl',1024);
     with
     load gd_sim5L_linpol0_p6s_20100120_221847.mat
     load gd_sim5L_linpol45_p6s_20100120_221925.mat
     g=pss_band_recos1(pulsar_6s(),'sim7_p6s.sbl',1024);
     The names of the two gds with the signals are: (sorry for the _p3s, which should be _p6s ...) sim5L_linpol0_p3s and sim5L_linpo45_p3s. You can put, to use simpler names and the same as before: g0=sim5L_linpol0_p3s and g45=sim5L_linpol45_p3s
     to have the same names as before.
     These noise data here are simulated, thus there is no need for the rough cleaning and for the Wiener (check it ! Look at the time data and spectra). Then proceed as for the other pulsars. Here results are good and this is due to the fact that we have 10 days of data (in fact the SNR of the injected pulsar is here roughly the same as those injected in the C7 data)

   – **General notes:**

     (a) Remember that typing the source name, e.g. **pulsar_6s**, in matlab you see its parameters. The relevant ones are : η,ψ, h_0 and the frequency.

     (b) After the parameters estimation:
     [*sour stat*]=estimate_psour(v5dat,v5sig0,v5sig45);
     typing **sour** you see the estimated parameters, to be compared with the input parameters (sour is a structure). Here also h_p and h_c are written and important.

     (c) Rough cleaning and Wiener are important to clean the data. The Wiener applies a weight to the data which is inversely proportional to the variance. It is interesting to compare results without these vetoes, or with only one of the two.. Results after the cleaning strongly depend on the data quality. C7 data were highly disturbed so the effect of the cleaning procedure is relevant. The comparison is easy: use **g, gclean, gw** as input to compute_5comp(). If you don't apply the Wiener to the noise then remove the *,wiener* argument to the call of compute_5comp for the v5sig0 and v5sig45 evaluation.

(d) Spectral estimation: to increase the frequency resolution (important in many cases) an over-resolution factor, say 2 or 4, can be applied. Spectra done with Snag have this feature (the second parameter in the window)

Notes to the upper limit evaluation Construct the noise cumulative distribution, using **filter_dist_mc**. This code produces the noise distribution after the matched filter, using a theoretical gaussian noise, with the measured variance. So the example is good but, for real analysis, the use of the real noise distribution is needed, as the "tail" of the distribution play a crucial role.
How to proceed ? Standard deviation:
y=y_gd(gw);
s=std(notzeros(y))
a=v5sig0/(2*pi);
b=v5sig45/(2*pi);
filter_dist_mc(s,a,b,0); The graph of the 1-cumsum(noise) will appear.
Then construct the detection statistics for the signal:
$SS = (norm(a))^4 * (norm(sour.hp))^2 + (norm(b))^4 * (norm(sour.hc))^2$ Check where this number is on the x-axis of the noise histogram. Read the corresponding y-axis value. This is the probablity that the observed SS is due to noise (but remember that the noise distribution is theoretical...so tail which are present in real data do not appears here.)

Suggestions for exercises on Doppler effect

- **Num. 3** Estimate the time T over which the Doppler effect becomes relevant, supposing a time less compared to one sidereal day.
  From the Doppler shift equations. The relevant part for this problem is the rotation effect, with daily sidereal period. $v_{rot} = \Omega_{rot} R_E$, and $\Delta\nu = \nu_0 \frac{\Delta v_{rot}}{c}$, with $\Delta v_{rot} = v_{rot}\Delta\theta = v_{rot}\Omega_{rot}T$. Over the time T, Δv_{rot} is the variation of the detector velocity in the direction of the source.
  Now we impose that $\Delta\nu_{max} = \frac{1}{T}$, is equal to $\nu_0 \cdot \frac{v_{rot}}{c}\Omega_{rot}T$. Now, evaluate T_{max}.
- **Num. 4** Estimate the time T needed to discriminate a monocromatic signal and a GW signal emitted from a source in the ecliptic pole.
  If the source is at the ecliptic pole then the velocity which enters is $v_{rot}cos(\phi_{1,2})$, with $\phi_1 = 90 - 23$, or $\phi_2 = 90 + 23$ degrees. Thus $\Delta\nu = \nu_0 \frac{v_{rot}}{c}(cos\phi_1 - cos\phi_2) = \frac{1}{T}$.
  Note: $cos(67^o) - cos(113^o) = 0.78 \approx 46\pi/180 = 0.8$

- **Num. 5** Estimate the obs time above which the spin-down becomes relevant. Simple ... $\Delta\nu = \dot{\nu}\, T > \frac{1}{T}$
- **Num. 6** Estimate the precision with which the source position can be determined.

  Two sources located at different position, e.g. separated by an angle $\Delta\phi$ produce a difference in the frequency shift which is: $\Delta\nu = \nu_0 \frac{v_{rot}}{c}\ (cos(\phi) - cos(\phi + \Delta\phi)) \approx \nu_0 \frac{v_{rot}}{c}\ sin(\phi) \cdot \Delta\phi = \frac{1}{T}$ The angular resolution depends on T