Instabilité des écoulements et introduction à la turbulence - ECL S7 FLE-a1
http://acoustique.ec-lyon.fr

TRAVAUX DIRIGÉS : ANALYSE DE SIGNAUX TURBULENTS

Turbulent subsonic round jet

Turbulent velocity signals have been measured using x-hot-wire anemometer in a round subsonic jet. The signals have been recorded in data files, refer to Table 1, and collected in the zip file *hwa.zip* to download.

$u_1 \& u_2$	$u_1 \& u_2$	$u_1 \& u_3$	$u_1 \& u_3$
$x_2 = 0, x_3 = 0$	$x_2 = D/2, x_3 = 0$	$x_2 = 0, x_3 = 0$	$x_2 = 0, x_3 = D/2$
data1.dat	data2.dat	data3.dat	data4.dat

Matlab script to read the data

```
load data1.m
t = data1( :,1);
u1 = data1( :,2);
u2 = data1( :,3);
```

TABLE 1 – Turbulent velocity signals for a free round jet of diameter $D = 50$ mm and exit velocity $U_j = 30$ m.s^{-1}, corresponding to a Reynolds number value of $\mathrm{Re}_D \simeq 10^5$. The Cartesian coordinates are denoted by (x_1, x_2, x_3) where x_1 is associated with the jet axis, and (u_1, u_2, u_3) are the velocity components. The hot-wire probe is located at $x_1 = 2D$.

You can conduct your study fairly freely, but the following points may be considered :

1. For a point located in the jet shear layer ($x_2 = D/2$ ou $x_3 = D/2$), extract the time signature of $u_1'(t)$, calculate $u'_{1\mathrm{rms}} = (\overline{u_1'^2})^{1/2}$, the skewness S_1 and the flatness T_1 coefficients defined by

$$S_1 = \frac{\overline{u_1'^3}}{(\overline{u_1'^2})^{3/2}} \qquad T_1 = \frac{\overline{u_1'^4}}{(\overline{u_1'^2})^2}$$

2. Compare your results with a Gaussian distribution for the longitudinal velocity u_1' and comment.

3. What is the following quantity $\left(\overline{u_1^2} - \overline{u_1}^2\right)^{1/2}$? Compare this definition to the classical expression of the standard deviation.

4. Calculate the previous statistics for the time derivative of the longitudinal velocity component $\partial u_1'/\partial t$.

5. Calculate the available Reynolds tensor components $\overline{u_i' u_j'}$ on the jet axis and in the shear layer. Comment your results, what is expected ?

6. Consider now the probability density function of $u_i' u_j'$ in the shear layer. Plot this function and comment your result.

7. By splitting the time signal $u_1'(t)$ into n segments, that are considered as n statistically independent realizations, verify that turbulence is stationary. What is the appropriate time length of each segment ?

8. Calculate the time correlation function $R(\tau)$ of the signal $u_i'(t)$ in the jet shear layer and the integral time Θ, defined as

$$R(\tau) = \frac{\overline{u_1'(t)u_1'(t+\tau)}}{\overline{u_1'^2}} \qquad \text{and} \qquad \Theta = \int_0^{+\infty} R(\tau)d\tau$$

9. How can you link the integral time scale Θ to the longitudinal integral length scale L, obtained from the space correlation of u_1' in the x_1 direction.

10. Calculate and plot the power spectral density of u_1' and u_2' measured at $x_2 = D/2$ (hint : there is a short introduction to Matlab for signal processing on the website).