$$\Phi_X(j\omega) = e^{-\omega^2\sigma_X^2/2+j\omega m_X}. \tag{210}$$

The moment theorem yields for orders $n = 1, \ldots, 4$ (see Eqs.135 to 138)

$$\begin{aligned} m_X^{(1)} &= m_X, & (211)\\ m_X^{(2)} &= \sigma_X^2 + m_X^2, & (212)\\ m_X^{(3)} &= 3\sigma_X^2 m_X + m_X^3, & (213)\\ m_X^{(4)} &= 3\sigma_X^4 + 6\sigma_X^2 m_X^2 + m_X^4. & (214)\end{aligned}$$

The **cumulants** were obtained from the cumulant generating function (see Eq.126)

$$\Psi_X(s) = \ln \Phi_X(s) = s^2\sigma_X^2/2 + s m_X \tag{215}$$

as (cf. Eqs.142 to 145):

$$\begin{aligned} \lambda_X^{(0)} &= s^2\sigma_X^2/2 + s m_X\Big|_{s=0} = 0, & (216)\\ \lambda_X^{(1)} &= s\sigma_X^2 + m_X\Big|_{s=0} = m_X, & (217)\end{aligned}$$

$$\begin{aligned} \lambda_X^{(2)} &= \sigma_X^2\Big|_{s=0} = \sigma_X^2, & (218)\\ \lambda_X^{(n>2)} &= 0. & (219)\end{aligned}$$

Definition 2.37. Two jointly normally distributed RVs. *Two RVs X, Y are* **jointly normal** *or* **jointly Gaussian**, *denoted by $\mathcal{N}(m_X, m_Y, \sigma_X, \sigma_Y, c_{XY})$, if their joint pdf reads*

$$f_{XY}(x,y) = \frac{1}{2\pi\sigma_X\sigma_Y\sqrt{1-c_{XY}^2}} \cdot \exp\left\{-\frac{1}{2\left(1-c_{XY}^2\right)} \cdot \left[\frac{(x-m_X)^2}{\sigma_X^2} - 2c_{XY}\cdot\frac{(x-m_X)(y-m_Y)}{\sigma_X\sigma_Y} + \frac{(y-m_Y)^2}{\sigma_Y^2}\right]\right\} \tag{220}$$

where c_{XY} with $|c_{XY}| < 1$ denotes the correlation coefficient (see Eq.162).