The periodic motion of a disk freely falling in a tube

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This study is devoted to the rectilinear and periodic paths of an axisymmetric solid body (short-length cylinder and disk of diameter d, thickness h and aspect ratio $3 \leq \chi = d/h \leq 10$) falling in a vertical tube of diameter D. Three-dimensional trajectography was used to record the body motion (see figure 1). We investigated the influence of the confinement ratio ($S = d/D$) on the characteristics of the body motion, for different aspect ratios and Reynolds numbers ($80 < Re < 320$), and a density ratio between the fluid and the body close to unity. The critical Reynolds number for the onset of the periodic motion decreases with S in the case of thin bodies ($\chi = 10$), whereas it appears unaffected by S for thicker bodies ($\chi = 3$ and 6). For all aspect ratios, the mean fall velocity of the body decreases when S increases. The characteristics of the oscillatory motion are also strongly modified by the confinement ratio. A thick body ($\chi = 3$) tends to stabilize and to go back to a rectilinear path when the confinement ratio increases, while a thin body ($\chi = 10$) displays oscillations of growing amplitude with S until it touches the tube (at about $S = 0.5$). However, the amplitudes of the oscillatory motion of bodies with a given aspect ratio gather on a unique curve for all S (including the case with no confinement, $S = 0$), when plotted as a function of the relative distance of the Reynolds numbers of the bodies to the threshold of path instability for each confinement ratio S.

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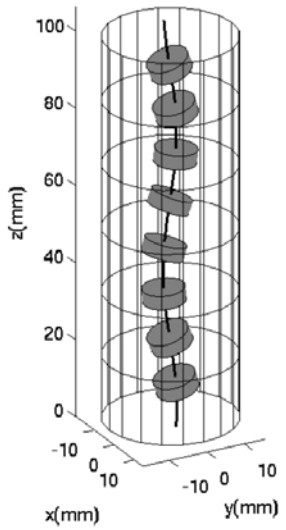

Figure 1: Three-dimensional view of the path of a body of aspect ratio $\chi = 3$ falling in a tube with $S = 0.32$ and $Re = 245$. The grid represents the wall of the tube.