Lee, Cunbiao; **Su, Zhuang**; **Zhong, Hongjie**; **Chen, Shiyi**; **Zhou, Mingde**; **Wu, Jiezhi**

Experimental investigation of freely falling thin disks. II: Transition of three-dimensional motion from zigzag to spiral. (English) Zbl 1294.76028

J. Fluid Mech. 732, 77-104 (2013).

Summary: The free-fall motion of a thin disk with small dimensionless moments of inertia ($I^* < 10^{-3}$) was investigated experimentally. The transition from two-dimensional zigzag motion to three-dimensional spiral motion occurs due to the growth of three-dimensional disturbances. Oscillations in the direction normal to the zigzag plane increase with the development of this instability. At the same time, the oscillation of the nutation angle decreases to zero and the angle remains constant. The effects of initial conditions (release angle) were investigated. Two kinds of transition modes, zigzag-spiral transition and zigzag-spiral-zigzag intermittence transition, were observed to be separated by a critical Reynolds number. In addition, the solution of the generalized Kirchhoff equations shows that the small I^* is responsible for the growth of disturbances in the third dimension (perpendicular to the planar motion).

For part I, see [the authors, ibid. 716, 228–250 (2013; Zbl 1284.76035)].

MSC:

76-05 Experimental work for problems pertaining to fluid mechanics
76D99 Incompressible viscous fluids
70E99 Dynamics of a rigid body and of multibody systems

Keywords:

aerodynamics; flow-structure interactions

Full Text: DOI

References:

[1] DOI: 10.1017/S0022112056000159 · Zbl 0074.20502 · doi:10.1017/S0022112056000159
[2] DOI: 10.1103/PhysRevLett.97.144508 · doi:10.1103/PhysRevLett.97.144508
[3] DOI: 10.1017/S0022112006002266 · Zbl 1165.76325 · doi:10.1017/S0022112006002266
[4] J.~Fluid Mech. 716 pp 228– (2012)
[5] Phys.~Rev.~Lett. 88 pp 014502– (2002)
[6] DOI: 10.1016/S0301-9322(02)00078-2 · Zbl 1137.76687 · doi:10.1016/S0301-9322(02)00078-2
[7] DOI: 10.1063/1.869919 · Zbl 1147.76451 · doi:10.1063/1.869919
[8] DOI: 10.1038/40817 · doi:10.1038/40817
[9] Annu.~Rev.~Fluid Mech. 32 pp 659– (2000)
[10] DOI: 10.1017/S0022112006003685 · Zbl 1108.76310 · doi:10.1017/S0022112006003685
[11] DOI: 10.1115/1.2909605 · Zbl 1146.76601 · doi:10.1115/1.2909605
[12] J.~Fluid Mech. 606 pp 209– (2008)
[13] DOI: 10.1017/jfm.2011.43 · Zbl 1241.76035 · doi:10.1017/jfm.2011.43
[14] DOI: 10.1063/1.2061609 · Zbl 1187.76152 · doi:10.1063/1.2061609
[15] Q.~J.~Mech.~Appl.~Maths 48 pp 401– (1995)
[16] DOI: 10.1017/S0022112009993934 · Zbl 1189.76152 · doi:10.1017/S0022112009993934
[17] DOI: 10.1103/PhysRevLett.102.134505 · doi:10.1103/PhysRevLett.102.134505
[18] DOI: 10.1063/1.2992126 · Zbl 1182.76328 · doi:10.1063/1.2992126
[19] Phys.~Fluids 17 pp 113302– (2007)
[20] DOI: 10.1017/jfm.2012.602 · Zbl 1284.76130 · doi:10.1017/jfm.2012.602
[21] DOI: 10.1063/1.4799179 · Zbl 06456348 · doi:10.1063/1.4799179

[22] DOI: 10.1103/PhysRevLett.81.345 · doi:10.1103/PhysRevLett.81.345

[23] DOI: 10.1017/S002211200500594X · Zbl 1082.76037 · doi:10.1017/S002211200500594X

[24] Phys.˜Fluids 23 pp 9– (2011)

[25] DOI: 10.1063/1.1711133 · Zbl 0116.18903 · doi:10.1063/1.1711133

[26] DOI: 10.1017/S0022112004008468 · Zbl 1073.76506 · doi:10.1017/S0022112004008468

[27] The behaviour of large particles falling in quiescent liquids (1969)

[28] DOI: 10.1063/1.864241 · doi:10.1063/1.864241

[29] DOI: 10.1017/S0022112071002738 · doi:10.1017/S0022112071002738

[30] DOI: 10.1103/PhysRevLett.93.144501 · doi:10.1103/PhysRevLett.93.144501