Supplementary material: Dynamical separation of spherical bodies in supersonic flow

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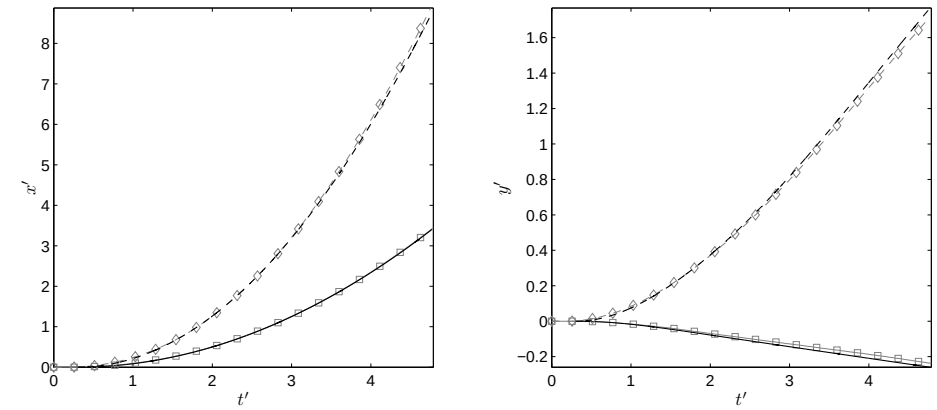
1. Further comparisons of unsteady experimental and computational results

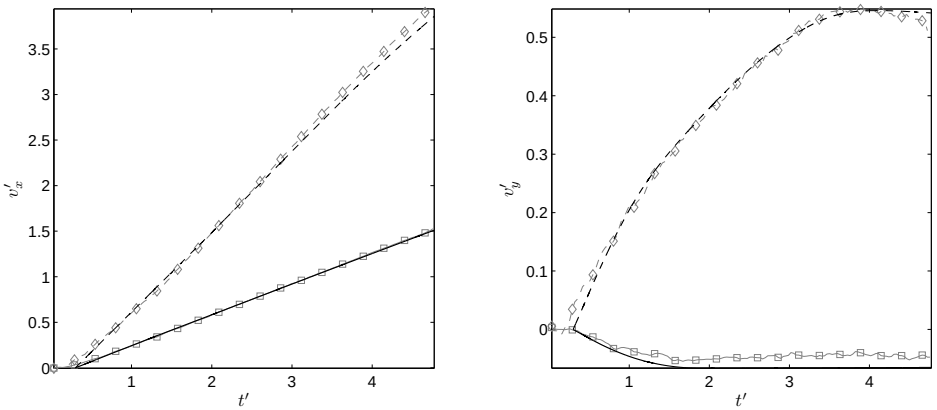
In figure 1 is shown a full nondimensional comparison of experimental and computational results for r_2/r_1=0.5 and θ_0=-0.1°, i.e., the configuration of the experiment shown in figure 9b of the full manuscript. Plotted are nondimensional displacements, nondimensional velocities, and force coefficients. The reader is referred to § 4.2 for a description of the methodology for comparing results.

2. Tabulated results from computational refinement study

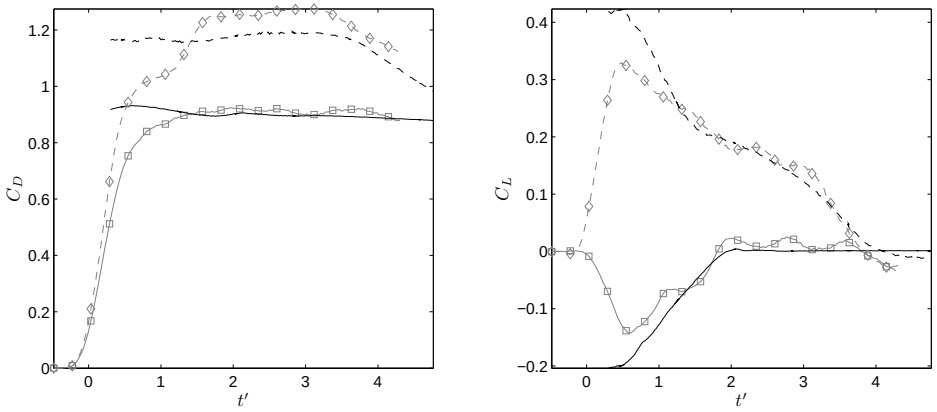
As further reference data, in tables 1 and 2 are tabulated results from the computational refinement study of § 3.2: provided are the x- and y-positions of the secondary and primary spheres, the velocities, and the integral hydrodynamic force components at $t = T + 4$ and $t = T + 12$, respectively. Both sphere centres remain essentially within the plane $z = 1$ throughout all runs and thus, besides some negligible variations to within the accuracy of the numerical method, $v_z \equiv 0$ and $f_z \equiv 0$ can be assumed.



(a) Normalised x- and y-displacements



(b) Normalized velocities



(c) Drag and lift coefficients

FIGURE 1. Comparison of experimental and computational results for r_2/r_1=0.5 and θ_0=-0.1°: —□—, experimental primary sphere; —, computational primary sphere; – –◇– –, experimental secondary sphere; – – –, computational secondary sphere. The normalised variables are: $t' = \sqrt{\rho_a/\rho_m}tV/r_1$, $x' = (x - x(0))/r_1$ and $y' = (y - y(0))/r_1$; $v_x' = \sqrt{\rho_m/\rho_a}v_x/V$ and $v_y' = \sqrt{\rho_m/\rho_a}v_y/V$; $C_D = 8a_x r/(3\rho_a V^2)$ and $C_L = 8a_y r/(3\rho_a V^2)$.

	Secondary						Primary					
#	x	y	$10\,v_x$	$10^2 v_y$	$10\,f_x$	$10\,f_y$	x	y	$10\,v_x$	$10^2 v_y$	f_x	$10^2 f_y$
1	0.5787	1.3821	1.107	2.692	0.6146	1.3372	0.4637	0.9752	0.5552	-0.995	1.2126	-6.237
2	0.5734	1.3864	1.086	2.860	0.6124	1.3337	0.4629	0.9756	0.5531	-0.958	1.2458	-4.358
3	0.5726	1.3875	1.081	2.893	0.6050	1.3211	0.4637	0.9759	0.5570	-0.949	1.2378	-3.654
4	0.5701	1.3887	1.069	2.924	0.5965	1.3238	0.4635	0.9761	0.5565	-0.930	1.2438	-2.881
5	0.5686	1.3892	1.063	2.933	0.5919	1.3191	0.4629	0.9762	0.5549	-0.921	1.2437	-2.499
6	0.5667	1.3895	1.054	2.933	0.5876	1.3070	0.4623	0.9764	0.5529	-0.911	1.2463	-2.056

TABLE 1. Positions, velocities, and integral hydrodynamic forces acting on the secondary and primary spheres at $t = T + 4$ for the six verification setups.

	Secondary						Primary					
#	x	y	$10\,v_x$	$10^2 v_y$	$10\,f_x$	$10\,f_y$	x	y	$10\,v_x$	$10^2 v_y$	f_x	$10^2 f_y$
1	2.3114	1.7769	3.158	7.040	5.146	0.9521	1.3307	0.8944	1.6109	-1.001	1.1899	0.0968
2	2.2589	1.7954	3.039	6.959	4.768	0.6825	1.3283	0.8986	1.6053	-0.953	1.2057	0.3427
3	2.2396	1.7940	2.999	6.802	4.659	0.5910	1.3352	0.9000	1.6169	-0.938	1.2207	0.2674
4	2.2108	1.7901	2.948	6.611	4.547	0.4738	1.3350	0.9019	1.6172	-0.918	1.2208	0.1671
5	2.1974	1.7864	2.925	6.472	4.539	0.4030	1.3337	0.9030	1.6168	-0.903	1.2209	0.2763
6	2.1821	1.7823	2.903	6.366	4.517	0.3757	1.3316	0.9041	1.6148	-0.892	1.2209	0.2477

TABLE 2. Positions, velocities, and integral hydrodynamic forces of the secondary and primary spheres at $t = T + 12$ for the six verification setups.