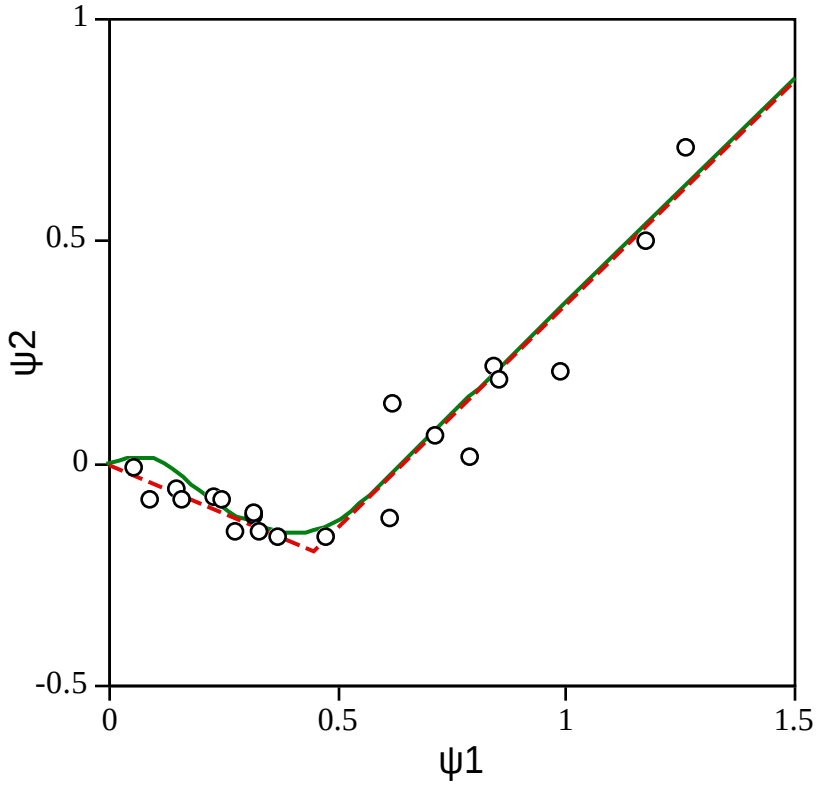
S.F. Foerster, M.Y. Louge, H. Chang, and K. Allia: "Measurements of the collision properties of Small Spheres," *Phys. Fluids* **6**(3), 1108-1115 (1994).

We describe an experiment to measure the properties of the collisions between two small spheres or between a small sphere and a semi-infinite flat wall. The apparatus releases the particles in a free-fall without initial spin. The impacts are modeled in terms of three coefficients. The first is the coefficient of normal restitution. The second represents the frictional properties of the contact surfaces. The last characterizes the restitution of the tangential components of the velocity of the contact point for impacts that do not involve sliding. The coefficients are calculated from stroboscopic photographs of the ballistics of the particles near the collision. The results establish that the collision model provides an accurate description of the dynamics of the impacts.

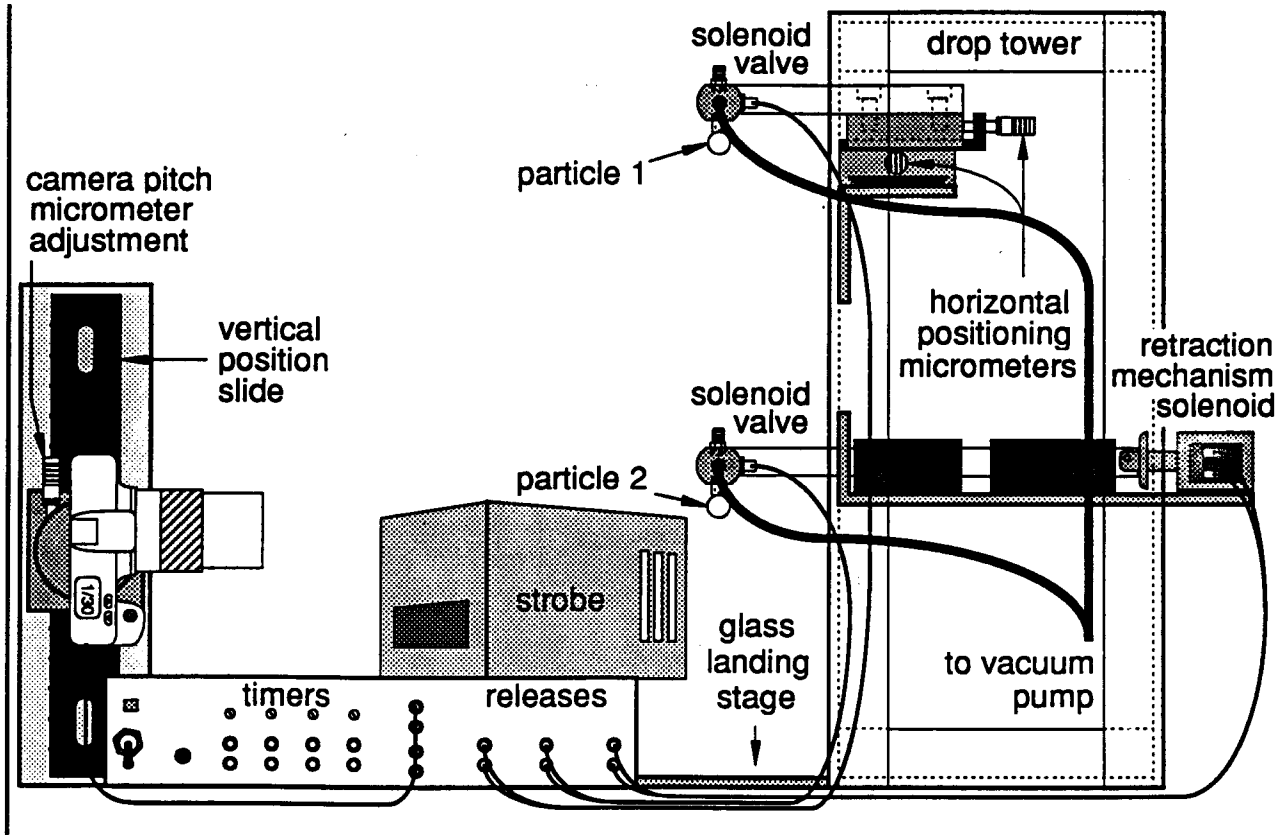
Figure excerpts



Results for binary collisions of 6mm acetate spheres.

Table 1. Sphere Properties

Material		Soda lime glass	Cellulose acetate
Finish		polished, grade "200"	ashed
Diameter (mm)		3.18 ± 0.03	5.99 ± 0.03
Density (g/cc)		2.5	1.319
Poisson's ratio		0.22	0.28 †
Young's modulus (N/m^2)		$7.1\ 10^{10}$	$3.2\ 10^{9}$ †
binary collisions	e	0.97 ± 0.01	0.87 ± 0.02
	μ	0.092 ± 0.006	0.25 ± 0.02
	β_0	0.44 ± 0.07	0.43 ± 0.06
Relative contact velocities		$0.64 \le \lvert\mathbf{g}.\mathbf{n}\rvert \le 1.2$ m/sec $0.06 \le \lvert\mathbf{g}.\mathbf{t}\rvert \le 0.41$ m/sec	$0.29 \le \lvert\mathbf{g}.\mathbf{n}\rvert \le 1.2$ m/sec $0.14 \le \lvert\mathbf{g}.\mathbf{t}\rvert \le 0.86$ m/sec
wall collisions	e	0.831 ± 0.009	0.891 ± 0.003
	μ	0.125 ± 0.007	0.208 ± 0.007
	β_0	0.31 ± 0.06	0.39 ± 0.07
Relative contact velocities		$1.0 \le \lvert\mathbf{g}.\mathbf{n}\rvert \le 1.7$ m/sec $0.24 \le \lvert\mathbf{g}.\mathbf{t}\rvert \le 0.81$ m/sec	$0.67 \le \lvert\mathbf{g}.\mathbf{n}\rvert \le 1.7$ m/sec $0.06 \le \lvert\mathbf{g}.\mathbf{t}\rvert \le 1.2$ m/sec
Manufacturer		Winsted Precision Ball Co.	Engineering Laboratories
Aluminum Plate		Density = 2.7 g/cc Young's modulus = $6.9\ 10^{10}$ N/m^2 Poisson's ratio = 0.33 Machine finish	
† Estimates, see Drake[6]			


solenoid valve
drop tower
particle 1
camera pitch micrometer adjustment
vertical position slide
horizontal positioning micrometers
retraction mechanism solenoid
solenoid valve
particle 2
strobe
glass landing stage
timers
releases
to vacuum pump