C12 Sphere's Collision - FORTRAN

Algorithmic Simulation / Time-oriented Model

Simulator: FORTRAN is used for the numerical calculations. The code for the algorithm is not longer as in a simulator (which is not necessary) or in a simulator environment, the numerical effects of the code are better known, and the code is very fast. Graphics is done by postprocessing in MATLAB.

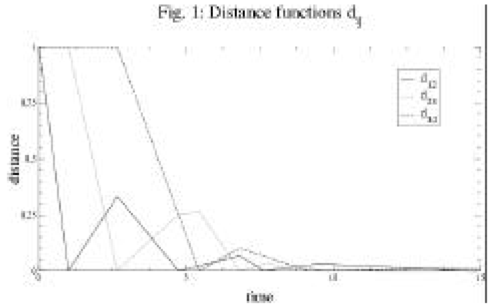
Model: A FORTRAN 90 program was used to (1) determine the next two spheres which will hit each other and (2) to update the positions and the velocities of the spheres after the collision according to the rules for partially elastic collisions. All calculations were carried out in double precision.

The program terminates if all relative velocities are not negative (no more collisions) or if the next two colliding spheres cannot be determined uniquely (two pairs of spheres are numerically equally likely to collide next). Assuming that the last pair of spheres to collide will not also be the next to collide, simplifies the algorithm. Additionally, only spheres with a negative relative velocity are considered:

```
!  previous hit of spheres 1 and 2
IF (.NOT. t12_log) THEN
  IF ( (v23 .LT. 0) .AND. (v34 .LT. 0) ) THEN
    IF (d23/v23 .EQ. d34/v34) THEN
      EXIT
    END IF
    t_neg_max = max( d23/v23 , d34/v34 )
    IF (t_neg_max .EQ. d23/v23) THEN
      nexthit = 23
    ELSE IF (t_neg_max .EQ. d34/v34) THEN
      nexthit = 34
    END IF
  ELSE IF ( v23 .LT. 0 ) THEN
    nexthit = 23
  ELSE IF ( v34 .LT. 0 ) THEN
    nexthit = 34  …………………….
```

Task a: Simulation in time domain / Final velocities: The final velocities in task a2 for e = 1 are $v_1 = v_2 = v_3 = 0$ and $v_4 = 1$. The lowest e-value which permits the program to exit the loop (all relative velocities ≥ 0) was 0.0811, with $v_i = 0.25000000$.

Fig. 1: Distance functions d_{ij}



Task b) Variation of restitution coefficient: The stepsize for the variation of e was 0.0001; Fig. 2 shows the number of collisions over e and Fig. 3 the final velocities of the spheres.

Since these figures also contain the final values for those simulations where the calculation were stopped because of numerical problems, the number of collisions in Fig. 2 should be considered as lower bounds. Additionally, for the reliable simulations (no more collisions) the final velocities of all spheres for e-values < 0.1770 are 0.25000000 practically.

Fig. 2: Number of collisions

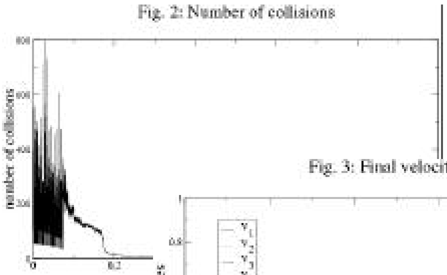
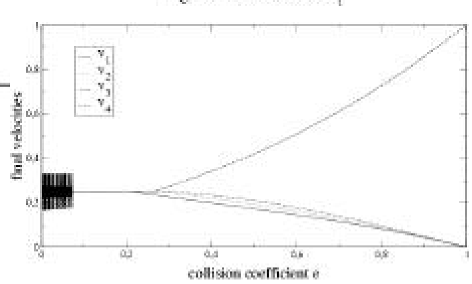


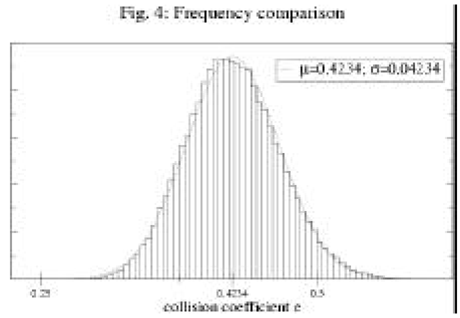
Fig. 3: Final velocities v_i



Task c: Boundary value problem / Statistical deviation of restitution coefficient. The boundary value problem was solved by bisection: $v_0 = v_4/2$ holds practically, if e = 0.5874010519682.

For task c2 the **R**-function rnorm was used to generate a set of 100000 random deviates. These e-values were used to calculate the distribution of the final value of v_4 (see Fig. 4). The statistical parameters are: $\acute{y}_4 = 0.4234$, s = 0.04234, 95 % conf. interval: [0.4231687,0.4236936]

Fig. 4: Frequency comparison



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