



# ATI STREAM COMPUTING SAMPLE

## N-Body Simulation

### 1 Overview

1.1 **Location** `$(ATISTREAMSDKSAMPLESROOT)\samples\openc1\cl\app`

1.2 **How to Run** See the *Getting Started* guide for how to build samples. You first must compile the sample.

Use the command line to change to the directory where the executable is located. The pre-compiled sample executable is at `$(ATISTREAMSDKSAMPLESROOT)\samples\openc1\bin\x86\` for 32-bit builds, and `$(ATISTREAMSDKSAMPLESROOT)\samples\openc1\bin\x86_64\` for 64-bit builds.

Type the following command(s).

1. `NBody`  
This runs with default options;  $p = 256$ .
2. `NBody -h`  
This prints the help file.

1.3 **Command Line Options** Table 1 lists, and briefly describes, the command line options.

**Table 1** Command Line Options

Short Form	Long Form	Description
-h	--help	Shows all command options and their respective meaning.
-q	--quiet	Quiet mode. Suppresses all text output.
-e	--verify	Verify results against reference implementation.
-v	--verbose	Verbose output.
-t	--timing	Print timing.
-x	--particles	Number of particles.
	--device	Devices on which the program is to be run. Acceptable values are <code>cpu</code> or <code>gpu</code> .

## 2 Introduction

An N-body simulation is a simulation of a large number of particles under the influence of physical forces such as gravity and coulomb forces. N-body simulations are used in various fields, including molecular dynamics, astrophysics, and Lagrangian mechanics.

The problem we seek to solve in this sample is a generalized problem of finding the collective motions of all the particles under the influence of forces between the bodies. This sample considers Newtonian forces between bodies and showcases the superior SIMD capabilities of AMD GPUs to solve N-body simulations in contrast to a CPU. A typical scenario is the motion of a large number of stars in a galaxy, starting from known initial conditions.

## 3 The N-Body Problem

This section provides a brief overview of the implemented N-body problem. The initial inputs to the problem are a set of  $n$  bodies,  $b_1, b_2, \dots, b_n$ , where each body  $b_i$  has a mass  $m_i$ , a velocity  $v_i$ , and position  $p_i$ . The distance between any two bodies,  $b_i$  and  $b_j$ , is written  $d_{ij}$ , we want to compute the new positions and velocity of each body after  $dT$  time elapsed and with softening factor  $f_c$ .

To calculate the new velocity and position

1. Calculate acceleration,  $a_i$ , effect on  $b_i$  due to each body,  $b_j$ :

$$a_i = \sum_{j=0}^{j=n} s * d_{ij}$$

where  $d_{ij}$  is distance between  $b_j$  and  $b_i$ .

The  $s$  in the previous equation is calculated as follows:

$$s = m_i * \left( \frac{1}{\sqrt{f_c * \overline{d_{ij}}}} \right)$$

Here:  $m_i$  is mass of  $b_i$

$f_c$  is softening factor

$\overline{d_{ij}}$  is the magnitude of distance vector

2. Calculate the new position and velocity from initial position ( $p_i$ ), velocity ( $v_i$ ) and calculated acceleration ( $a_i$ ):

$$p_i = p_i + v_i * dT + a_i * 0.5 * (dT)^2$$

$$v_i = v_i + a_i * dT$$

## 4 Implementation Details

Each work item calculates the position and velocity from the equation in 1, above. Shared memory is used to reduce memory bandwidth and to reuse data.

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