FDPS講習会
サンプルコード編

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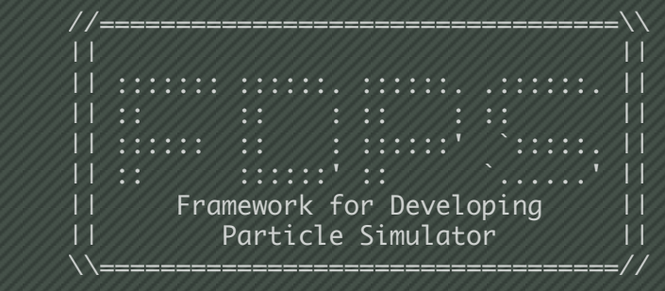

2016/07/06 FDPS講習会

コード構成

- ユーザーが書くべきもの
  - #include <particle_simulator.h>
  - 粒子クラスと必要なメンバ関数
  - 相互作用関数
  - 時間積分ルーチン
  - I/O (粒子クラスのI/Oと、FileHeaderクラス)

2016/07/06 FDPS講習会

```
//==================================\\
||                                  ||
|| ::::::: ::::::. ::::::. .::::::. ||
|| ::      ::    : ::    : ::      ||
|| ::::::  ::    : ::::::'  `::::.  ||
|| ::      ::::::' ::      `....'  ||
||    Framework for Developing      ||
||       Particle Simulator         ||
\\==================================//
```

サンプルコード

●今回のサンプルコードの内容

流体 (Smoothed Particle Hydrodynamics)

重力 (w/ and w/o Phantom-GRAPE (Tanikawa+, 2011; 2012))

●本スライドでは、重力を計算するコードを取り上げて解説する。

・時間積分法はleap-frog法

・初期条件はその場生成(ファイル読み込みではない)

・ファイル構成

user-defined.hpp

nbody.cpp


```
//================================\\
||                                ||
|| ::::::: ::::::. ::::::. .::::::. ||
|| ::      ::    : ::    : ::      ||
|| ::::::  ::    : ::::::'  `::::.  ||
|| ::      ::::::' ::      `....'  ||
||     Framework for Developing   ||
||       Particle Simulator       ||
\\================================//
```

user-defined.hpp

```
#pragma once
class FileHeader{
public:
    PS::S64 n_body;
    PS::F64 time;
    PS::S32 readAscii(FILE * fp) {
        fscanf(fp, "%lf\n", &time);
        fscanf(fp, "%lld\n", &n_body);
        return n_body;
    }
    void writeAscii(FILE* fp) const {
        fprintf(fp, "%e\n", time);
        fprintf(fp, "%lld\n", n_body);
    }
};

class FPGrav{
public:
    PS::S64    id;
    PS::F64    mass;
    PS::F64vec pos;
    PS::F64vec vel;
    PS::F64vec acc;
```

user-defined.hpp

```
#pragma once
class FileHeader{
public:
    PS::S64 n_body;
    PS::F64 time;
    PS::S32 readAscii(FILE * fp) {
        fscanf(fp, "%lf\n", &time);
        fscanf(fp, "%lld\n", &n_body);
        return n_body;
    }
    void writeAscii(FILE* fp) const {
        fprintf(fp, "%e\n", time);
        fprintf(fp, "%lld\n", n_body);
    }
};

class FPGrav{
public:
    PS::S64    id;
    PS::F64    mass;
    PS::F64vec pos;
    PS::F64vec vel;
    PS::F64vec acc;
```

クラス

user-defined.hpp

```
#pragma once
class FileHeader{
public:
    PS::S64 n_body;
    PS::F64 time;
    PS::S32 readAscii(FILE * fp) {
        fscanf(fp, "%lf\n", &time);
        fscanf(fp, "%lld\n", &n_body);
        return n_body;
    }
    void writeAscii(FILE* fp) const {
        fprintf(fp, "%e\n", time);
        fprintf(fp, "%lld\n", n_body);
    }
};

class FPGrav{
public:
    PS::S64    id;
    PS::F64    mass;
    PS::F64vec pos;
    PS::F64vec vel;
    PS::F64vec acc;
```

FileHeaderクラス

```
class FPGrav{
public:
    PS::S64    id;
    PS::F64    mass;
    PS::F64vec pos;
    PS::F64vec vel;
    PS::F64vec acc;
    PS::F64    pot;

    static PS::F64 eps;

    PS::F64vec getPos() const {
        return pos;
    }

    PS::F64 getCharge() const {
        return mass;
    }

    void copyFromFP(const FPGrav & fp){
        mass = fp.mass;
        pos  = fp.pos;
    }

    void copyFromForce(const FPGrav & force) {
        acc = force.acc;
        pot = force.pot;
    }
```

粒子クラス

```
16
17  class FPGrav{
18  public:
19      PS::S64    id;
20      PS::F64    mass;
21      PS::F64vec pos;
22      PS::F64vec vel;
23      PS::F64vec acc;
24      PS::F64    pot;
25
26      static PS::F64 eps;
27
28      PS::F64vec getPos() const {
29          return pos;
30      }
31
32      PS::F64 getCharge() const {
33          return mass;
34      }
35
36      void copyFromFP(const FPGrav & fp){
37          mass = fp.mass;
38          pos  = fp.pos;
39      }
40
41      void copyFromForce(const FPGrav & force) {
42          acc = force.acc;
43          pot = force.pot;
44      }
```

粒子物理量

```
PS::S64    id;
PS::F64    mass;
PS::F64vec pos;
PS::F64vec vel;
PS::F64vec acc;
PS::F64    pot;

static PS::F64 eps;

PS::F64vec getPos() const {
    return pos;
}

PS::F64 getCharge() const {
    return mass;
}

void copyFromFP(const FPGrav & fp){
    mass = fp.mass;
    pos  = fp.pos;
}

void copyFromForce(const FPGrav & force) {
    acc = force.acc;
    pot = force.pot;
}

void clear() {
    acc = 0.0;
```

FDPSにデータを渡すための

メンバ関数

```
}

void clear() {
    acc = 0.0;
    pot = 0.0;
}

void writeAscii(FILE* fp) const {
    fprintf(fp, "%lld\t%g\t%g\t%g\t%g\t%g\t%g\t%g\n",
            this->id, this->mass,
            this->pos.x, this->pos.y, this->pos.z,
            this->vel.x, this->vel.y, this->vel.z);
}

void readAscii(FILE* fp) {
    fscanf(fp, "%lld\t%lf\t%lf\t%lf\t%lf\t%lf\t%lf\t%lf\n",
           &this->id, &this->mass,
           &this->pos.x, &this->pos.y, &this->pos.z,
           &this->vel.x, &this->vel.y, &this->vel.z);
    }

};

#ifdef ENABLE_PHANTOM_GRAPE_X86

template <class TParticleJ>
```

I/Oメンバ関数

```
            &this->vel.x, &this->vel.y, &this->vel.z);
    }

};
```

相互作用
テンプレート関数
(w/ Phantom-GRAPE)

```
#ifdef ENABLE_PHANTOM_GRAPE_X86


template <class TParticleJ>
void CalcGravity(const FPGrav * iptcl,
                 const PS::S32 ni,
                 const TParticleJ * jptcl,
                 const PS::S32 nj,
                 FPGrav * force) {
  const PS::S32 nipipe = ni;
  const PS::S32 njpipe = nj;
  PS::F64 (*xi)[3] = (PS::F64 (*)[3])malloc(sizeof(PS::F64) * nipipe * PS::DIMENSION);
  PS::F64 (*ai)[3] = (PS::F64 (*)[3])malloc(sizeof(PS::F64) * nipipe * PS::DIMENSION);
  PS::F64  *pi     = (PS::F64  *    )malloc(sizeof(PS::F64) * nipipe);
  PS::F64 (*xj)[3] = (PS::F64 (*)[3])malloc(sizeof(PS::F64) * njpipe * PS::DIMENSION);
  PS::F64  *mj     = (PS::F64  *    )malloc(sizeof(PS::F64) * njpipe);
  for(PS::S32 i = 0; i < ni; i++) {
      xi[i][0] = iptcl[i].getPos()[0];
      xi[i][1] = iptcl[i].getPos()[1];
      xi[i][2] = iptcl[i].getPos()[2];
      ai[i][0] = 0.0;
      ai[i][1] = 0.0;
      ai[i][2] = 0.0;
```

```
        xj[j][2] = jptcl[j].getPos()[2];
        mj[j]    = jptcl[j].getCharge();
        xj[j][0] = jptcl[j].pos[0];
        xj[j][1] = jptcl[j].pos[1];
        xj[j][2] = jptcl[j].pos[2];
        mj[j]    = jptcl[j].mass;
    }
    PS::S32 devid = PS::Comm::getThreadNum();
    g5_set_xmjMC(devid, 0, nj, xj, mj);
    g5_set_nMC(devid, nj);
    g5_calculate_force_on_xMC(devid, xi, ai, pi, ni);
    for(PS::S32 i = 0; i < ni; i++) {
        force[i].acc[0] += ai[i][0];
        force[i].acc[1] += ai[i][1];
        force[i].acc[2] += ai[i][2];
        force[i].pot    -= pi[i];
    }
    free(xi);
    free(ai);
    free(pi);
    free(xj);
    free(mj);
}

#else

template <class TParticleJ>
void CalcGravity(const FPGrav * ep_i,
```

```
template <class TParticleJ>
void CalcGravity(const FPGrav * ep_i,
                 const PS::S32 n_ip,
                 const TParticleJ * ep_j,
                 const PS::S32 n_jp,
                 FPGrav * force) {
    PS::F64 eps2 = FPGrav::eps * FPGrav::eps;
    for(PS::S32 i = 0; i < n_ip; i++){
        PS::F64vec xi = ep_i[i].getPos();
        PS::F64vec ai = 0.0;
        PS::F64 poti = 0.0;
        for(PS::S32 j = 0; j < n_jp; j++){
            PS::F64vec rij    = xi - ep_j[j].getPos();
            PS::F64    r3_inv = rij * rij + eps2;
            PS::F64    r_inv  = 1.0/sqrt(r3_inv);
            r3_inv  = r_inv * r_inv;
            r_inv  *= ep_j[j].getCharge();
            r3_inv *= r_inv;
            ai     -= r3_inv * rij;
            poti   -= r_inv;
        }
        force[i].acc += ai;
        force[i].pot += poti;
    }
}

#endif
```

相互作用

テンプレート関数

(w/o Phantom-GRAPE)

```
22  template <class TParticleJ>
23  void CalcGravity(const FPGrav * ep_i,
24                   const PS::S32 n_ip,
25                   const TParticleJ * ep_j,
26                   const PS::S32 n_jp,
27                   FPGrav * force) {
28      PS::F64 eps2 = FPGrav::eps * FPGrav::eps;
29      for(PS::S32 i = 0; i < n_ip; i++){
30          PS::F64vec xi = ep_i[i].getPos();
31          PS::F64vec ai = 0.0;
32          PS::F64 poti = 0.0;
33          for(PS::S32 j = 0; j < n_jp; j++){
34              PS::F64vec rij    = xi - ep_j[j].getPos();
35              PS::F64    r3_inv = rij * rij + eps2;
36              PS::F64    r_inv  = 1.0/sqrt(r3_inv);
37              r3_inv  = r_inv * r_inv;
38              r_inv  *= ep_j[j].getCharge();
39              r3_inv *= r_inv;
40              ai     -= r3_inv * rij;
41              poti   -= r_inv;
42          }
43          force[i].acc += ai;
44          force[i].pot += poti;
45      }
46  }
47
48  #endif
```

相互作用

テンプレート関数

(w/o Phantom-GRAPE)

```
22  template <class TParticleJ>
23  void CalcGravity(const FPGrav * ep_i,
24                   const PS::S32 n_ip,
25                   const TParticleJ * ep_j,
26                   const PS::S32 n_jp,
27                   FPGrav * force) {
28      PS::F64 eps2 = FPGrav::eps * FPGrav::eps;
29      for(PS::S32 i = 0; i < n_ip; i++){
30          PS::F64vec xi = ep_i[i].getPos();
31          PS::F64vec ai = 0.0;
32          PS::F64 poti = 0.0;
33          for(PS::S32 j = 0; j < n_jp; j++){
34              PS::F64vec rij    = xi - ep_j[j].getPos();
35              PS::F64    r3_inv = rij * rij + eps2;
36              PS::F64    r_inv  = 1.0/sqrt(r3_inv);
37              r3_inv  = r_inv * r_inv;
38              r_inv  *= ep_j[j].getCharge();
39              r3_inv *= r_inv;
40              ai     -= r3_inv * rij;
41              poti   -= r_inv;
42          }
43          force[i].acc += ai;
44          force[i].pot += poti;
45      }
46  }
47
48  #endif
```

相互作用

テンプレート関数

(w/o Phantom-GRAPE)

相互作用template関数

- 本当は2つ(Super Particleからの寄与と通常Particleからの寄与)書く必要がある。

- 今回はどちらも相互作用形としては同じなので、templateを使って1つで済ます。

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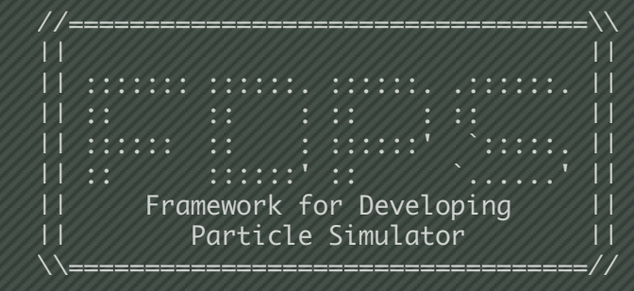


nbody.cpp

```
#include<iostream>
#include<fstream>
#include<unistd.h>
#include<sys/stat.h>
#include<particle_simulator.hpp>
#ifdef ENABLE_PHANTOM_GRAPE_X86
#include <gp5util.h>
#endif
#ifdef ENABLE_GPU_CUDA
#define MULTI_WALK
#include"force_gpu_cuda.hpp"
#endif
#include "user-defined.hpp"

void makeColdUniformSphere(const PS::F64 mass_glb,
                           const PS::S64 n_glb,
                           const PS::S64 n_loc,
                           PS::F64 *& mass,
                           PS::F64vec *& pos,
                           PS::F64vec *& vel,
                           const PS::F64 eng = -0.25,
                           const PS::S32 seed = 0) {

```

nbody.cpp

```cpp
#include<iostream>
#include<fstream>
#include<unistd.h>
#include<sys/stat.h>
#include<particle_simulator.hpp>
#ifdef ENABLE_PHANTOM_GRAPE_X86
#include <gp5util.h>
#endif
#ifdef ENABLE_GPU_CUDA
#define MULTI_WALK
#include"force_gpu_cuda.hpp"
#endif
#include "user-defined.hpp"

void makeColdUniformSphere(const PS::F64 mass_glb,
                           const PS::S64 n_glb,
                           const PS::S64 n_loc,
                           PS::F64 *& mass,
                           PS::F64vec *& pos,
                           PS::F64vec *& vel,
                           const PS::F64 eng = -0.25,
                           const PS::S32 seed = 0) {

```

FDPSのinclude

```
79      delete [] pos;
80      delete [] vel;
81  }
82
83  template<class Tpsys>
84  void kick(Tpsys & system,
85            const PS::F64 dt) {
86      PS::S32 n = system.getNumberOfParticleLocal();
87      for(PS::S32 i = 0; i < n; i++) {
88          system[i].vel  += system[i].acc * dt;
89      }
90  }
91
92  template<class Tpsys>
93  void drift(Tpsys & system,
94             const PS::F64 dt) {
95      PS::S32 n = system.getNumberOfParticleLocal();
96      for(PS::S32 i = 0; i < n; i++) {
97          system[i].pos  += system[i].vel * dt;
98      }
99  }
100
101 template<class Tpsys>
102 void calcEnergy(const Tpsys & system,
103                 PS::F64 & etot,
104                 PS::F64 & ekin,
105                 PS::F64 & epot,
106                 const bool clear=true){
```

leap-frog法による
時間積分

```
78      delete [] mass;
79      delete [] pos;
80      delete [] vel;
81  }
82
83  template<class Tpsys>
84  void kick(Tpsys & system,
85            const PS::F64 dt) {
86      PS::S32 n = system.getNumberOfParticleLocal();
87      for(PS::S32 i = 0; i < n; i++) {
88          system[i].vel  += system[i].acc * dt;
89      }
90  }
91
92  template<class Tpsys>
93  void drift(Tpsys & system,
94             const PS::F64 dt) {
95      PS::S32 n = system.getNumberOfParticleLocal();
96      for(PS::S32 i = 0; i < n; i++) {
97          system[i].pos  += system[i].vel * dt;
98      }
99  }
100
101 template<class Tpsys>
102 void calcEnergy(const Tpsys & system,
103                 PS::F64 & etot,
104                 PS::F64 & ekin,
105                 PS::F64 & epot,
106                 const bool clear=true){
```

getNumberOfParticleLocal()
で粒子数が取得できる

```
78      delete [] mass;
79      delete [] pos;
80      delete [] vel;
81  }
82
83  template<class Tpsys>
84  void kick(Tpsys & system,
85            const PS::F64 dt) {
86      PS::S32 n = system.getNumberOfParticleLocal();
87      for(PS::S32 i = 0; i < n; i++) {
88          system[i].vel  += system[i].acc * dt;
89      }
90  }
91
92  template<class Tpsys>
93  void drift(Tpsys & system,
94             const PS::F64 dt) {
95      PS::S32 n = system.getNumberOfParticleLocal();
96      for(PS::S32 i = 0; i < n; i++) {
97          system[i].pos  += system[i].vel * dt;
98      }
99  }
100
101 template<class Tpsys>
102 void calcEnergy(const Tpsys & system,
103                 PS::F64 & etot,
104                 PS::F64 & ekin,
105                 PS::F64 & epot,
106                 const bool clear=true){
```

粒子群クラスに[i]をつけると
i粒子のデータが取得できる

```
163 PS::F64 FPGrav::eps = 1.0/32.0;
164
165 int main(int argc, char *argv[]) {
166     std::cout<<std::setprecision(15);
167     std::cerr<<std::setprecision(15);
168
169     PS::Initialize(argc, argv);
170     PS::F32 theta = 0.5;
171     PS::S32 n_leaf_limit = 8;
172     PS::S32 n_group_limit = 64;
173     PS::F32 time_end = 10.0;
174     PS::F32 dt = 1.0 / 128.0;
175     PS::F32 dt_diag = 1.0 / 8.0;
176     PS::F32 dt_snap = 1.0;
177     char dir_name[1024];
178     PS::S64 n_tot = 1024;
179     PS::S32 c;
180     sprintf(dir_name,"./result");
181     opterr = 0;
182     while((c=getopt(argc,argv,"i:o:d:D:t:T:l:n:N:hs:")) != -1){
183         switch(c){
184         case 'o':
185             sprintf(dir_name,optarg);
186             break;
187         case 't':
188             theta = atof(optarg);
189             std::cerr << "theta =" << theta << std::endl;
190             break;
191         case 'T':
```

メイン関数開始

```
163 PS::F64 FPGrav::eps = 1.0/32.0;
164
165 int main(int argc, char *argv[]) {
166     std::cout<<std::setprecision(15);
167     std::cerr<<std::setprecision(15);
168
169     PS::Initialize(argc, argv);
170     PS::F32 theta = 0.5;
171     PS::S32 n_leaf_limit = 8;
172     PS::S32 n_group_limit = 64;
173     PS::F32 time_end = 10.0;
174     PS::F32 dt = 1.0 / 128.0;
175     PS::F32 dt_diag = 1.0 / 8.0;
176     PS::F32 dt_snap = 1.0;
177     char dir_name[1024];
178     PS::S64 n_tot = 1024;
179     PS::S32 c;
180     sprintf(dir_name,"./result");
181     opterr = 0;
182     while((c=getopt(argc,argv,"i:o:d:D:t:T:l:n:N:hs:")) != -1){
183         switch(c){
184         case 'o':
185             sprintf(dir_name,optarg);
186             break;
187         case 't':
188             theta = atof(optarg);
189             std::cerr << "theta =" << theta << std::endl;
190             break;
191         case 'T':
```

FDPS初期化

コマンドライン
引数の解析

```
PS::S32 c;
sprintf(dir_name,"./result");
opterr = 0;
while((c=getopt(argc,argv,"i:o:d:D:t:T:l:n:N:hs:")) != -1){
    switch(c){
    case 'o':
        sprintf(dir_name,optarg);
        break;
    case 't':
        theta = atof(optarg);
        std::cerr << "theta =" << theta << std::endl;
        break;
    case 'T':
        time_end = atof(optarg);
        std::cerr << "time_end = " << time_end << std::endl;
        break;
    case 's':
        dt = atof(optarg);
        std::cerr << "time_step = " << dt << std::endl;
        break;
    case 'd':
        dt_diag = atof(optarg);
        std::cerr << "dt_diag = " << dt_diag << std::endl;
        break;
    case 'D':
        dt_snap = atof(optarg);
        std::cerr << "dt_snap = " << dt_snap << std::endl;
        break;
    case 'l':
```

```
209         std::cerr << "n_leaf_limit = " << n_leaf_limit << std::endl;
210         break;
211     case 'n':
212         n_group_limit = atoi(optarg);
213         std::cerr << "n_group_limit = " << n_group_limit << std::endl;
214         break;
215     case 'N':
216         n_tot = atoi(optarg);
217         std::cerr << "n_tot = " << n_tot << std::endl;
218         break;
219     case 'h':
220         if(PS::Comm::getRank() == 0) {
221             printHelp();
222         }
223         PS::Finalize();
224         return 0;
225     default:
226         if(PS::Comm::getRank() == 0) {
227             std::cerr<<"No such option! Available options are here."<<std::endl;
228             printHelp();
229         }
230         PS::Abort();
231     }
232 }
233
234 makeOutputDirectory(dir_name);
235
236 std::ofstream fout_eng;
```

粒子群クラスの
生成・初期化

```
246
247     PS::ParticleSystem<FPGrav> system_grav;
248     system_grav.initialize();
249     PS::S32 n_loc    = 0;
250     PS::F32 time_sys = 0.0;
251     if(PS::Comm::getRank() == 0) {
252         setParticlesColdUniformSphere(system_grav, n_tot, n_loc);
253     } else {
254         system_grav.setNumberOfParticleLocal(n_loc);
255     }
256
257     const PS::F32 coef_ema = 0.3;
258     PS::DomainInfo dinfo;
259     dinfo.initialize(coef_ema);
260     dinfo.collectSampleParticle(system_grav);
261     dinfo.decomposeDomain();
262     system_grav.exchangeParticle(dinfo);
263     n_loc = system_grav.getNumberOfParticleLocal();
264
265 #ifdef ENABLE_PHANTOM_GRAPE_X86
266     g5_open();
267     g5_set_eps_to_all(FPGrav::eps);
268 #endif
269
270     PS::TreeForForceLong<FPGrav, FPGrav, FPGrav>::Monopole tree_grav;
271     tree_grav.initialize(n_tot, theta, n_leaf_limit, n_group_limit);
272 #ifdef MULTI_WALK
273     const PS::S32 n_walk_limit = 200;
274     const PS::S32 tag_max = 1;
```

```
246
247     PS::ParticleSystem<FPGrav> system_grav;
248     system_grav.initialize();
249     PS::S32 n_loc    = 0;
250     PS::F32 time_sys = 0.0;
251     if(PS::Comm::getRank() == 0) {
252         setParticlesColdUniformSphere(system_grav, n_tot, n_loc);
253     } else {
254         system_grav.setNumberOfParticleLocal(n_loc);
255     }
256
257     const PS::F32 coef_ema = 0.3;
258     PS::DomainInfo dinfo;
259     dinfo.initialize(coef_ema);
260     dinfo.collectSampleParticle(system_grav);
261     dinfo.decomposeDomain();
262     system_grav.exchangeParticle(dinfo);
263     n_loc = system_grav.getNumberOfParticleLocal();
264
265 #ifdef ENABLE_PHANTOM_GRAPE_X86
266     g5_open();
267     g5_set_eps_to_all(FPGrav::eps);
268 #endif
269
270     PS::TreeForForceLong<FPGrav, FPGrav, FPGrav>::Monopole tree_grav;
271     tree_grav.initialize(n_tot, theta, n_leaf_limit, n_group_limit);
272 #ifdef MULTI_WALK
273     const PS::S32 n_walk_limit = 200;
274     const PS::S32 tag_max = 1;
```

ドメイン情報の
生成・初期化
領域分割

```
268 #endif
269
270     PS::TreeForForceLong<FPGrav, FPGrav, FPGrav>::Monopole tree_grav;
271     tree_grav.initialize(n_tot, theta, n_leaf_limit, n_group_limit);
272 #ifdef MULTI_WALK
273     const PS::S32 n_walk_limit = 200;
274     const PS::S32 tag_max = 1;
275     tree_grav.calcForceAllAndWriteBackMultiWalk(DispatchKernelWithSP,
276                                                 RetrieveKernel,
277                                                 tag_max,
278                                                 system_grav,
279                                                 dinfo,
280                                                 n_walk_limit);
281 #else
282     tree_grav.calcForceAllAndWriteBack(CalcGravity<FPGrav>,
283                                        CalcGravity<PS::SPJMonopole>,
284                                        system_grav,
285                                        dinfo);
286 #endif
287     PS::F64 Epot0, Ekin0, Etot0, Epot1, Ekin1, Etot1;
288     calcEnergy(system_grav, Etot0, Ekin0, Epot0);
289     PS::F64 time_diag = 0.0;
290     PS::F64 time_snap = 0.0;
291     PS::S64 n_loop = 0;
292     PS::S32 id_snap = 0;
293     while(time_sys < time_end){
294         if( (time_sys >= time_snap) || ( (time_sys + dt) - time_snap ) > (time_snap - time_sys)
295             char filename[256];
```

相互作用ツリークラスの
生成・初期化

```
#endif

    PS::TreeForForceLong<FPGrav, FPGrav, FPGrav>::Monopole tree_grav;
    tree_grav.initialize(n_tot, theta, n_leaf_limit, n_group_limit);
#ifdef MULTI_WALK
    const PS::S32 n_walk_limit = 200;
    const PS::S32 tag_max = 1;
    tree_grav.calcForceAllAndWriteBackMultiWalk(DispatchKernelWithSP,
                                                RetrieveKernel,
                                                tag_max,
                                                system_grav,
                                                dinfo,
                                                n_walk_limit);
#else
    tree_grav.calcForceAllAndWriteBack(CalcGravity<FPGrav>,
                                       CalcGravity<PS::SPJMonopole>,
                                       system_grav,
                                       dinfo);
#endif
    PS::F64 Epot0, Ekin0, Etot0, Epot1, Ekin1, Etot1;
    calcEnergy(system_grav, Etot0, Ekin0, Epot0);
    PS::F64 time_diag = 0.0;
    PS::F64 time_snap = 0.0;
    PS::S64 n_loop = 0;
    PS::S32 id_snap = 0;
    while(time_sys < time_end){
        if( (time_sys >= time_snap) || ( (time_sys + dt) - time_snap ) > (time_snap - time_sys)
            char filename[256];
```

相互作用関数を用いた
力の計算

```
289     PS::F64 time_diag = 0.0;
290     PS::F64 time_snap = 0.0;
291     PS::S64 n_loop = 0;
292     PS::S32 id_snap = 0;
293     while(time_sys < time_end){
294         if( (time_sys >= time_snap) || ( (time_sys + dt) - time_snap ) > (time_snap - time_sys) )
295             char filename[256];
296             sprintf(filename, "%s/%04d.dat", dir_name, id_snap++);
297             FileHeader header;
298             header.time   = time_sys;
299             header.n_body = system_grav.getNumberOfParticleGlobal();
300             system_grav.writeParticleAscii(filename, header);
301             time_snap += dt_snap;
302         }
303
304         calcEnergy(system_grav, Etot1, Ekin1, Epot1);
305
306         if(PS::Comm::getRank() == 0){
307             if( (time_sys >= time_diag) || ( (time_sys + dt) - time_diag ) > (time_diag - time_sy
308                 fout_eng << time_sys << "   " << (Etot1 - Etot0) / Etot0 << std::endl;
309                 fprintf(stderr, "time: %10.7f energy error: %+e\n",
310                         time_sys, (Etot1 - Etot0) / Etot0);
311                 time_diag += dt_diag;
312             }
313         }
314
315
316         kick(system_grav, dt * 0.5);
```

時間積分

```
316         kick(system_grav, dt * 0.5);
317
318         time_sys += dt;
319         drift(system_grav, dt);
320
321         if(n_loop % 4 == 0){
322             dinfo.decomposeDomainAll(system_grav);
323         }
324
325         system_grav.exchangeParticle(dinfo);
326 #ifdef MULTI_WALK
327         tree_grav.calcForceAllAndWriteBackMultiWalk(DispatchKernelWithSP,
328                                                     RetrieveKernel,
329                                                     tag_max,
330                                                     system_grav,
331                                                     dinfo,
332                                                     n_walk_limit,
333                                                     true);
334 #else
335         tree_grav.calcForceAllAndWriteBack(CalcGravity<FPGrav>,
336                                            CalcGravity<PS::SPJMonopole>,
337                                            system_grav,
338                                            dinfo);
339 #endif
340
341         kick(system_grav, dt * 0.5);
342
343         n_loop++;
```

```
326 #ifdef MULTI_WALK
327         tree_grav.calcForceAllAndWriteBackMultiWalk(DispatchKernelWithSP,
328                                                     RetrieveKernel,
329                                                     tag_max,
330                                                     system_grav,
331                                                     dinfo,
332                                                     n_walk_limit,
333                                                     true);
334 #else
335         tree_grav.calcForceAllAndWriteBack(CalcGravity<FPGrav>,
336                                            CalcGravity<PS::SPJMonopole>,
337                                            system_grav,
338                                            dinfo);
339 #endif
340
341         kick(system_grav, dt * 0.5);
342
343         n_loop++;
344     }
345
346 #ifdef ENABLE_PHANTOM_GRAPE_X86
347     g5_close();
348 #endif
349
350     PS::Finalize();
351     return 0;
352 }
```

FDPS終了

```
326   #ifdef MULTI_WALK
327         tree_grav.calcForceAllAndWriteBackMultiWalk(DispatchKernelWithSP,
328                                                     RetrieveKernel,
329                                                     tag_max,
330                                                     system_grav,
331                                                     dinfo,
332                                                     n_walk_limit,
333                                                     true);
334   #else
335         tree_grav.calcForceAllAndWriteBack(CalcGravity<FPGrav>,
336                                            CalcGravity<PS::SPJMonopole>,
337                                            system_grav,
338                                            dinfo);
339   #endif
340
341         kick(system_grav, dt * 0.5);
342
343         n_loop++;
344      }
345
346   #ifdef ENABLE_PHANTOM_GRAPE_X86
347      g5_close();
348   #endif
349
350      PS::Finalize();
351      return 0;
352 352行！
```

最後に

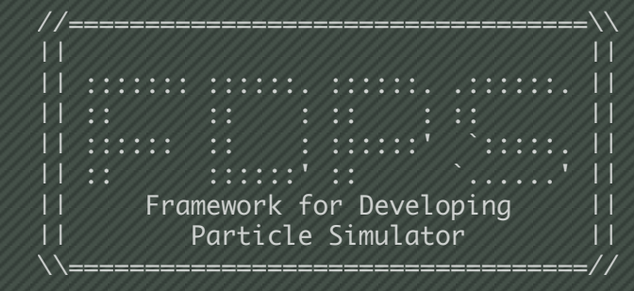
●ユーザーが書かなければならないのは大体これくらい。

→重力の場合は352+148行で終わる。

●コード内に並列化を意識するようなところは無かった。

→**コンパイルの方法を切り替えるだけで、**
OpenMPやMPIを切り替えられる。

2016/07/06 FDPS講習会



実習の流れ

●詳しくはFDPS講習会の手引を御覧ください。
(http://www.jmlab.jp/?p=650)

●実習用のFOCUSスパコンにログインし、サンプルコードを
(1)並列化無し (2)OpenMP (3)OpenMP + MPI
の3パターンについてコンパイル・実行

【計算内容】重力
cold collapse
流体 (Smoothed Particle Hydrodynamics法)
adiabatic sphere collapse

その後結果の解析