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c-----------------------------------------------------------------------
      subroutine PPGPPUSHF2L(ppart,fxy,kpic,ncl,ihole,noff,nyp,qbm,dt,ek
     1,nx,ny,mx,my,idimp,nppmx,nxv,nypmx,mx1,mxyp1,ntmax,irc)
c for 2d code, this subroutine updates particle co-ordinates and
c velocities using leap-frog scheme in time and first-order linear
c interpolation in space, with periodic boundary conditions
c also determines list of particles which are leaving this tile
c OpenMP version using guard cells, for distributed data
c data read in tiles
c particles stored segmented array
c 42 flops/particle, 12 loads, 4 stores
c input: all except ncl, ihole, irc, output: ppart, ncl, ihole, ek, irc
c equations used are:
c vx(t+dt/2) = vx(t-dt/2) + (q/m)*fx(x(t),y(t))*dt,
c vy(t+dt/2) = vy(t-dt/2) + (q/m)*fy(x(t),y(t))*dt,
c where q/m is charge/mass, and
c x(t+dt) = x(t) + vx(t+dt/2)*dt, y(t+dt) = y(t) + vy(t+dt/2)*dt
c fx(x(t),y(t)) and fy(x(t),y(t)) are approximated by interpolation from
c the nearest grid points:
c fx(x,y) = (1-dy)*((1-dx)*fx(n,m)+dx*fx(n+1,m)) + dy*((1-dx)*fx(n,m+1)
c    + dx*fx(n+1,m+1))
c fy(x,y) = (1-dy)*((1-dx)*fy(n,m)+dx*fy(n+1,m)) + dy*((1-dx)*fy(n,m+1)
c    + dx*fy(n+1,m+1))
c where n,m = leftmost grid points and dx = x-n, dy = y-m
c ppart(1,n,m) = position x of particle n in partition in tile m
c ppart(2,n,m) = position y of particle n in partition in tile m
c ppart(3,n,m) = velocity vx of particle n in partition in tile m
c ppart(4,n,m) = velocity vy of particle n in partition in tile m
c fxy(1,j,k) = x component of force/charge at grid (j,kk)
c fxy(2,j,k) = y component of force/charge at grid (j,kk)
c in other words, fxy are the convolutions of the electric field
c over the particle shape, where kk = k + noff - 1
c kpic(k) = number of particles in tile k
c ncl(i,k) = number of particles going to destination i, tile k
c ihole(1,:,k) = location of hole in array left by departing particle
c ihole(2,:,k) = destination of particle leaving hole
c ihole(1,1,k) = ih, number of holes left (error, if negative)
c noff = lowermost global gridpoint in particle partition.
c nyp = number of primary (complete) gridpoints in particle partition
c qbm = particle charge/mass
c dt = time interval between successive calculations
c kinetic energy/mass at time t is also calculated, using
c ek = .125*sum((vx(t+dt/2)+vx(t-dt/2))**2+(vy(t+dt/2)+vy(t-dt/2))**2)
c nx/ny = system length in x/y direction
c mx/my = number of grids in sorting cell in x/y
c idimp = size of phase space = 4
c nppmx = maximum number of particles in tile
c nxv = first dimension of field array, must be >= nx+1
c nypmx = maximum size of particle partition, including guard cells.
c mx1 = (system length in x direction - 1)/mx + 1
c mxyp1 = mx1*myp1, where myp1=(partition length in y direction-1)/my+1
c ntmax = size of hole array for particles leaving tiles
c irc = maximum overflow, returned only if error occurs, when irc > 0
c optimized version
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      implicit none
      integer noff, nyp, nx, ny, mx, my, idimp, nppmx, nxv, nypmx
      integer mx1, mxyp1, ntmax, irc
      real qbm, dt, ek
      real ppart, fxy
      integer kpic, ncl, ihole
      dimension ppart(idimp,nppmx,mxyp1), fxy(2,nxv,nypmx)
      dimension kpic(mxyp1), ncl(8,mxyp1)
      dimension ihole(2,ntmax+1,mxyp1)
c local data
      integer MXV, MYV
      parameter(MXV=33,MYV=33)
      integer noffp, moffp, nppp
      integer mnoff, i, j, k, ih, nh, nn, mm
      real qtm, dxp, dyp, amx, amy
      real x, y, dx, dy, vx, vy
      real anx, any, edgelx, edgely, edgerx, edgery
      real sfxy
      dimension sfxy(2,MXV,MYV)
c     dimension sfxy(2,mx+1,my+1)
      double precision sum1, sum2
      qtm = qbm*dt
      anx = real(nx)
      any = real(ny)
      sum2 = 0.0d0
c error if local array is too small
c     if ((mx.ge.MXV).or.(my.ge.MYV)) return
c loop over tiles
!$OMP PARALLEL DO
!$OMP& PRIVATE(i,j,k,noffp,moffp,nppp,nn,mm,ih,nh,mnoff,x,y,dxp,dyp,amx,
!$OMP& amy,dx,dy,vx,vy,edgelx,edgely,edgerx,edgery,sum1,sfxy)
!$OMP& REDUCTION(+:sum2)
      do 50 k = 1, mxyp1
      noffp = (k - 1)/mx1
      moffp = my*noffp
      noffp = mx*(k - mx1*noffp - 1)
      nppp = kpic(k)
      nn = min(mx,nx-noffp)
      mm = min(my,nyp-moffp)
      edgelx = noffp
      edgerx = noffp + nn
      edgely = noff + moffp
      edgery = noff + moffp + mm
      ih = 0
      nh = 0
      mnoff = moffp + noff - 1
c load local fields from global array
      do 20 j = 1, mm+1
      do 10 i = 1, nn+1
      sfxy(1,i,j) = fxy(1,i+noffp,j+moffp)
      sfxy(2,i,j) = fxy(2,i+noffp,j+moffp)
   10 continue
   20 continue
c clear counters
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      do 30 j = 1, 8
      ncl(j,k) = 0
   30 continue
      sum1 = 0.0d0
c loop over particles in tile
      do 40 j = 1, nppp
c find interpolation weights
      x = ppart(1,j,k)
      y = ppart(2,j,k)
      nn = x
      mm = y
      dxp = x - real(nn)
      dyp = y - real(mm)
      nn = nn - noffp + 1
      mm = mm - mnoff
      amx = 1.0 - dxp
      amy = 1.0 - dyp
c find acceleration
      dx = amx*sfxy(1,nn,mm)
      dy = amx*sfxy(2,nn,mm)
      dx = amy*(dxp*sfxy(1,nn+1,mm) + dx)
      dy = amy*(dxp*sfxy(2,nn+1,mm) + dy)
      vx = amx*sfxy(1,nn,mm+1)
      vy = amx*sfxy(2,nn,mm+1)
      dx = dx + dyp*(dxp*sfxy(1,nn+1,mm+1) + vx)
      dy = dy + dyp*(dxp*sfxy(2,nn+1,mm+1) + vy)
c new velocity
      vx = ppart(3,j,k)
      vy = ppart(4,j,k)
      dx = vx + qtm*dx
      dy = vy + qtm*dy
c average kinetic energy
      vx = vx + dx
      vy = vy + dy
      sum1 = sum1 + (vx*vx + vy*vy)
      ppart(3,j,k) = dx
      ppart(4,j,k) = dy
c new position
      dx = x + dx*dt
      dy = y + dy*dt
c find particles going out of bounds
      mm = 0
c count how many particles are going in each direction in ncl
c save their address and destination in ihole
c use periodic boundary conditions and check for roundoff error
c mm = direction particle is going
      if (dx.ge.edgerx) then
         if (dx.ge.anx) dx = dx - anx
         mm = 2
      else if (dx.lt.edgelx) then
         if (dx.lt.0.0) then
            dx = dx + anx
            if (dx.lt.anx) then
               mm = 1
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            else
               dx = 0.0
            endif
         else
            mm = 1
         endif
      endif
      if (dy.ge.edgery) then
         if (dy.ge.any) dy = dy - any
         mm = mm + 6
      else if (dy.lt.edgely) then
         if (dy.lt.0.0) then
            dy = dy + any
            if (dy.lt.any) then
               mm = mm + 3
            else
               dy = 0.0
            endif
         else
            mm = mm + 3
         endif
      endif
c set new position
      ppart(1,j,k) = dx
      ppart(2,j,k) = dy
c increment counters
      if (mm.gt.0) then
         ncl(mm,k) = ncl(mm,k) + 1
         ih = ih + 1
         if (ih.le.ntmax) then
            ihole(1,ih+1,k) = j
            ihole(2,ih+1,k) = mm
         else
            nh = 1
         endif
      endif
      sum2 = sum2 + sum1
   40 continue
c set error and end of file flag
c ihole overflow
      if (nh.gt.0) then
         irc = ih
         ih = -ih
      endif
      ihole(1,1,k) = ih
   50 continue
!$OMP END PARALLEL DO
c normalize kinetic energy
      ek = ek + 0.125*sum2
      return
      end
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c-----------------------------------------------------------------------
      subroutine PPGPPOST2L(ppart,q,kpic,noff,qm,idimp,nppmx,mx,my,nxv,
     1nypmx,mx1,mxyp1)
c for 2d code, this subroutine calculates particle charge density
c using first-order linear interpolation, periodic boundaries
c OpenMP version using guard cells, for distributed data
c data deposited in tiles
c particles stored segmented array
c 17 flops/particle, 6 loads, 4 stores
c input: all, output: q
c charge density is approximated by values at the nearest grid points
c q(n,m)=qm*(1.-dx)*(1.-dy)
c q(n+1,m)=qm*dx*(1.-dy)
c q(n,m+1)=qm*(1.-dx)*dy
c q(n+1,m+1)=qm*dx*dy
c where n,m = leftmost grid points and dx = x-n, dy = y-m
c ppart(1,n,m) = position x of particle n in partition in tile m
c ppart(2,n,m) = position y of particle n in partition in tile m
c q(j,k) = charge density at grid point (j,kk),
c where kk = k + noff - 1
c kpic = number of particles per tile
c noff = lowermost global gridpoint in particle partition.
c qm = charge on particle, in units of e
c idimp = size of phase space = 4
c nppmx = maximum number of particles in tile
c mx/my = number of grids in sorting cell in x/y
c nxv = first dimension of charge array, must be >= nx+1
c nypmx = maximum size of particle partition, including guard cells.
c mx1 = (system length in x direction - 1)/mx + 1
c mxyp1 = mx1*myp1, where myp1=(partition length in y direction-1)/my+1
      implicit none
      integer noff, idimp, nppmx, mx, my, nxv, nypmx, mx1, mxyp1
      real qm
      real ppart, q
      integer kpic
      dimension ppart(idimp,nppmx,mxyp1), q(nxv,nypmx), kpic(mxyp1)
c local data
      integer MXV, MYV
      parameter(MXV=33,MYV=33)
      integer noffp, moffp, nppp
      integer mnoff, i, j, k, nn, mm
      real x, y, dxp, dyp, amx, amy
      real sq
c     dimension sq(MXV,MYV)
      dimension sq(mx+1,my+1)
c error if local array is too small
c     if ((mx.ge.MXV).or.(my.ge.MYV)) return
c loop over tiles
!$OMP PARALLEL DO
!$OMP& PRIVATE(i,j,k,noffp,moffp,nppp,mnoff,nn,mm,x,y,dxp,dyp,amx,amy,
!$OMP& sq)
      do 80 k = 1, mxyp1
      noffp = (k - 1)/mx1
      moffp = my*noffp
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      noffp = mx*(k - mx1*noffp - 1)
      nppp = kpic(k)
      mnoff = moffp + noff - 1
c zero out local accumulator
      do 20 j = 1, my+1
      do 10 i = 1, mx+1
      sq(i,j) = 0.0
   10 continue
   20 continue
c loop over particles in tile
      do 30 j = 1, nppp
c find interpolation weights
      x = ppart(1,j,k)
      y = ppart(2,j,k)
      nn = x
      mm = y
      dxp = qm*(x - real(nn))
      dyp = y - real(mm)
      nn = nn - noffp + 1
      mm = mm - mnoff
      amx = qm - dxp
      amy = 1.0 - dyp
c deposit charge within tile to local accumulator
      x = sq(nn,mm) + amx*amy
      y = sq(nn+1,mm) + dxp*amy
      sq(nn,mm) = x
      sq(nn+1,mm) = y
      x = sq(nn,mm+1) + amx*dyp
      y = sq(nn+1,mm+1) + dxp*dyp
      sq(nn,mm+1) = x
      sq(nn+1,mm+1) = y
   30 continue
c deposit charge to interior points in global array
      nn = min(mx,nxv-noffp)
      mm = min(my,nypmx-moffp)
      do 50 j = 2, mm
      do 40 i = 2, nn
      q(i+noffp,j+moffp) = q(i+noffp,j+moffp) + sq(i,j)
   40 continue
   50 continue
c deposit charge to edge points in global array
      mm = min(my+1,nypmx-moffp)
      do 60 i = 2, nn
!$OMP ATOMIC
      q(i+noffp,1+moffp) = q(i+noffp,1+moffp) + sq(i,1)
      if (mm > my) then
!$OMP ATOMIC
         q(i+noffp,mm+moffp) = q(i+noffp,mm+moffp) + sq(i,mm)
      endif
   60 continue
      nn = min(mx+1,nxv-noffp)
      do 70 j = 1, mm
!$OMP ATOMIC
      q(1+noffp,j+moffp) = q(1+noffp,j+moffp) + sq(1,j)
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      if (nn > mx) then
!$OMP ATOMIC
         q(nn+noffp,j+moffp) = q(nn+noffp,j+moffp) + sq(nn,j)
      endif
   70 continue
   80 continue
!$OMP END PARALLEL DO
      return
      end
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