GRChombo Meeting Spring 2022

Tagging Criteria

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Adaptive Mesh Refinement (AMR)

- One technique for adding resolution

- AMR refinement

  - In regions of (almost) arbitrary shape/size

  - At any point in time, anywhere in box

  - Small *emergent* features always well-resolved

  - Little unnecessary regridding

  - Grid spacing ratio between levels in GRChombo is (*ref_ratio*) 2

- Comes at cost

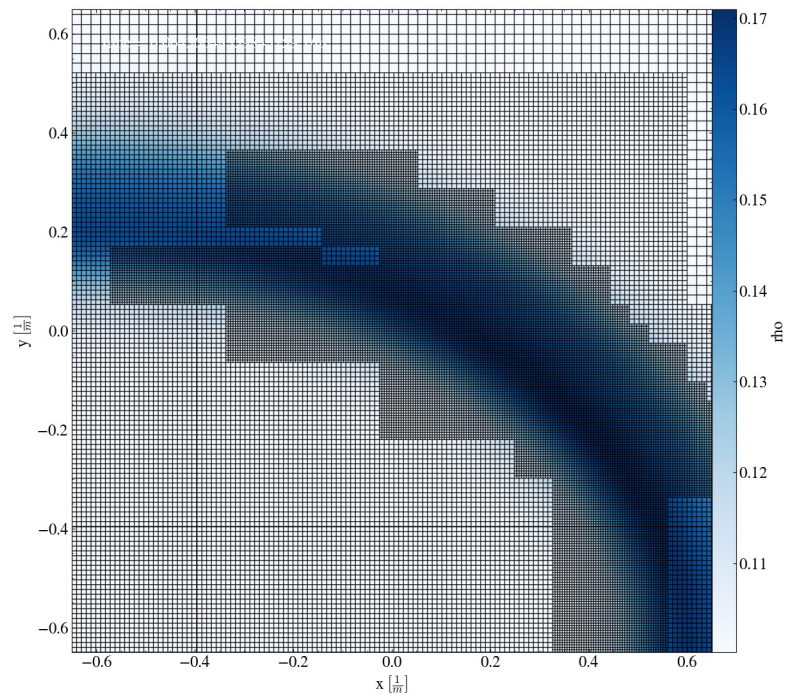 - E.g. interpolation errors, reflections at refinement boundary
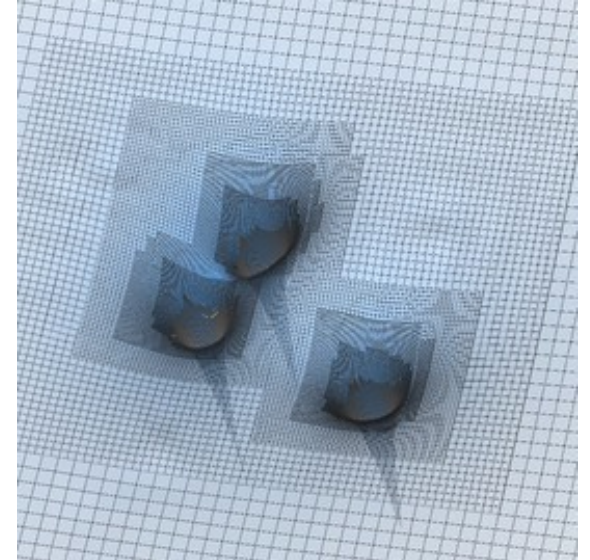
Adaptive Mesh Refinement (AMR)

- Parameters

  - Grid spacing ratio between levels (*ref_ratio*), 2 in GRChombo

  - *max_level* sets finest level

  - Shape limited by maximum and minimum size of box (*max_box_size and min_box_size/block_factor*)

  - Frequency of regridding is controlled by *regrid_interval*

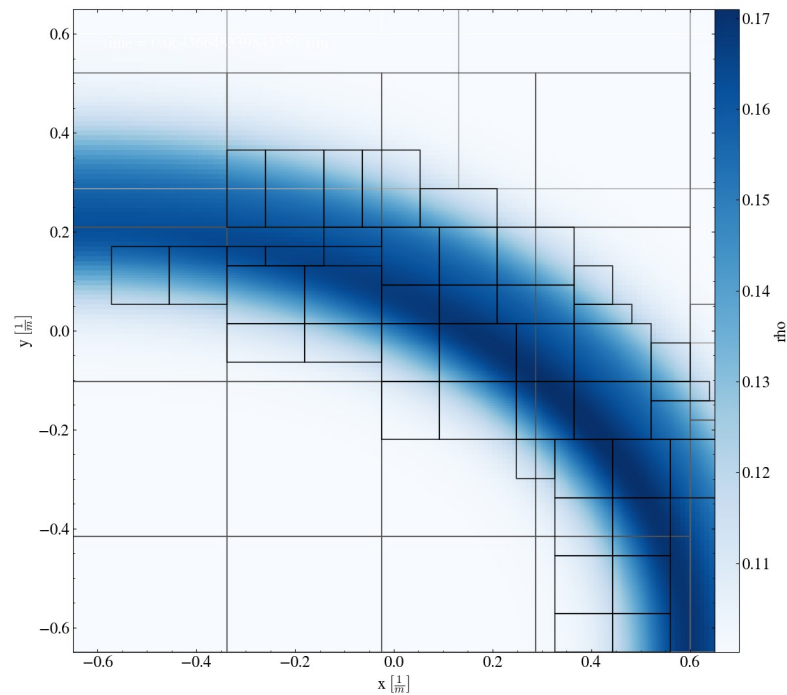   - Regrid on level l forces regrid on all finer levels > l
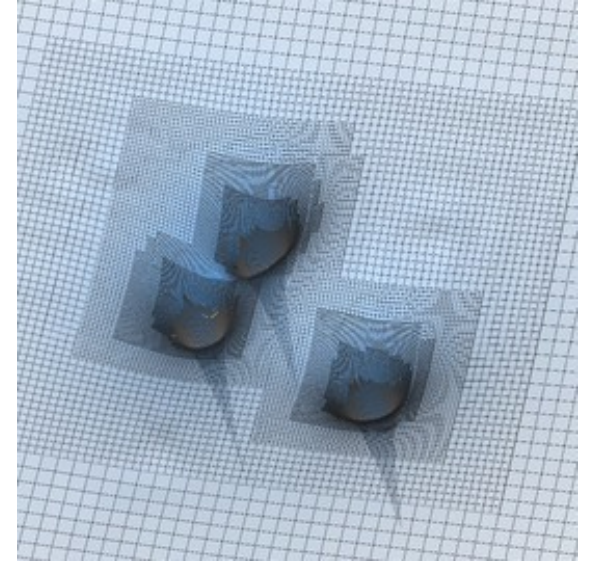
Adaptive Mesh Refinement (AMR)

Cell edges
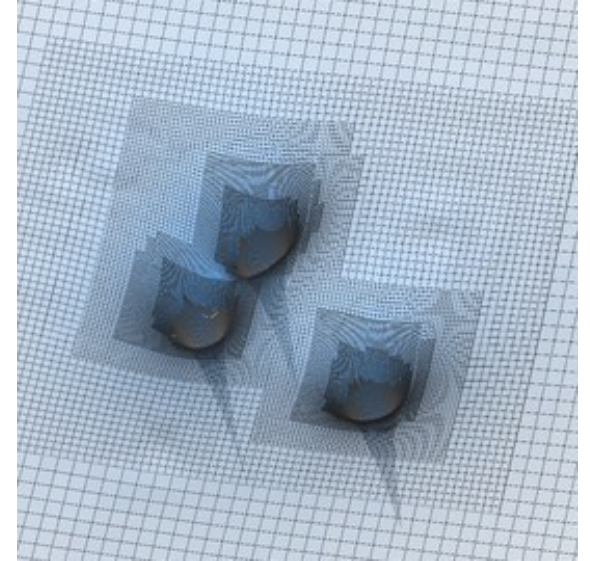
Box edges

Adaptive Mesh Refinement (AMR)

- Parameters

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  - *max_level* sets finest level

  - Shape limited by maximum and minimum size of box (*max_box_size and min_box_size/block_factor*)

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    - Regrid on level l forces regrid on all finer levels > l

Tagging

- Before regridding on a given given level l, cells are tagged according to tagging criterion $C(\mathcal{F}) \rightarrow \tau$

- $\mathcal{F}$ is set of cell's coordinates and all fields and 1st/2nd derivatives in the cell, subset in practice

- Cell is tagged if $\tau > \tau_R$

- τ_R is pre-specified threshold value
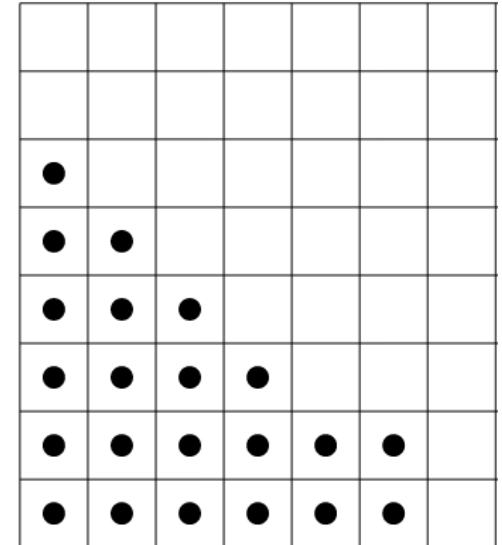
Tagging

- Found in Source/TaggingCriteria, called in ExampleLevel.cpp

- Member vars: grid spacing, derivatives, user-defined thresholds

- Lines 37-41: in this case, regridding based on first derivatives of phi, K

- Lines 43-44: definition of tagging criterion

  - user-defined threshold

  - m_dx so criterion is smaller at higher levels

```cpp
class PhiAndKTaggingCriterion
{
  protected:
    const double m_dx;
    const FourthOrderDerivatives m_deriv;
    const double m_threshold_phi;
    const double m_threshold_K;

  public:
    PhiAndKTaggingCriterion(double dx, double threshold_phi, double threshold_K)
        : m_dx(dx), m_deriv(dx), m_threshold_phi(threshold_phi),
          m_threshold_K(threshold_K){};

    template <class data_t> void compute(Cell<data_t> current_cell) const
    {
        Tensor<1, data_t> d1_phi;
        FOR(idir) m_deriv.diff1(d1_phi, current_cell, idir, c_phi);

        Tensor<1, data_t> d1_K;
        FOR(idir) m_deriv.diff1(d1_K, current_cell, idir, c_K);

        data_t mod_d1_phi = 0;
        data_t mod_d1_K = 0;
        FOR(idir)
        {
            mod_d1_phi += d1_phi[idir] * d1_phi[idir];
            mod_d1_K += d1_K[idir] * d1_K[idir];
        }

        data_t criterion = m_dx * (sqrt(mod_d1_phi) / m_threshold_phi +
                                   sqrt(mod_d1_K) / m_threshold_K);

        // Write back into the flattened Chombo box
        current_cell.store_vars(criterion, 0);
    }
};
```

Tagging tips

- Other information can be used to tweak tagging criterion

  - Apparent Horizon location

  - Stop regridding outside some radius

- Keep refinement boundaries away from regions of physical interest
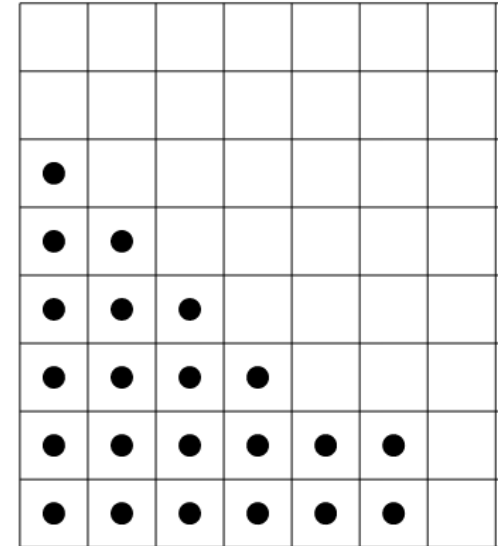
References

- Radia et al. (2021)

- Katy's thesis

- Berger & Rigoutsos (1991)

- Slides Miren 2020