EXTREME MASS RATIO INSPIRALS (EMRIs)

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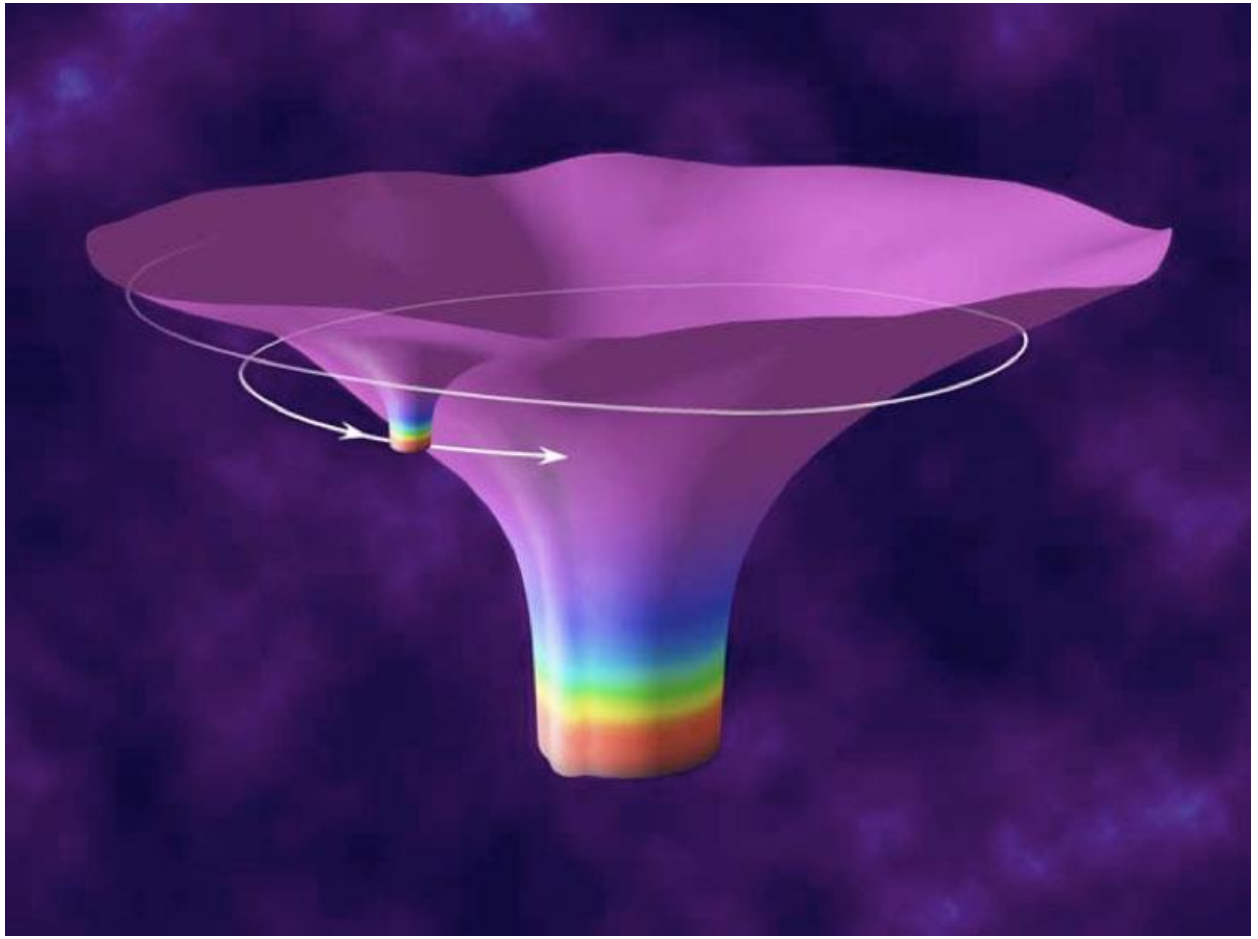
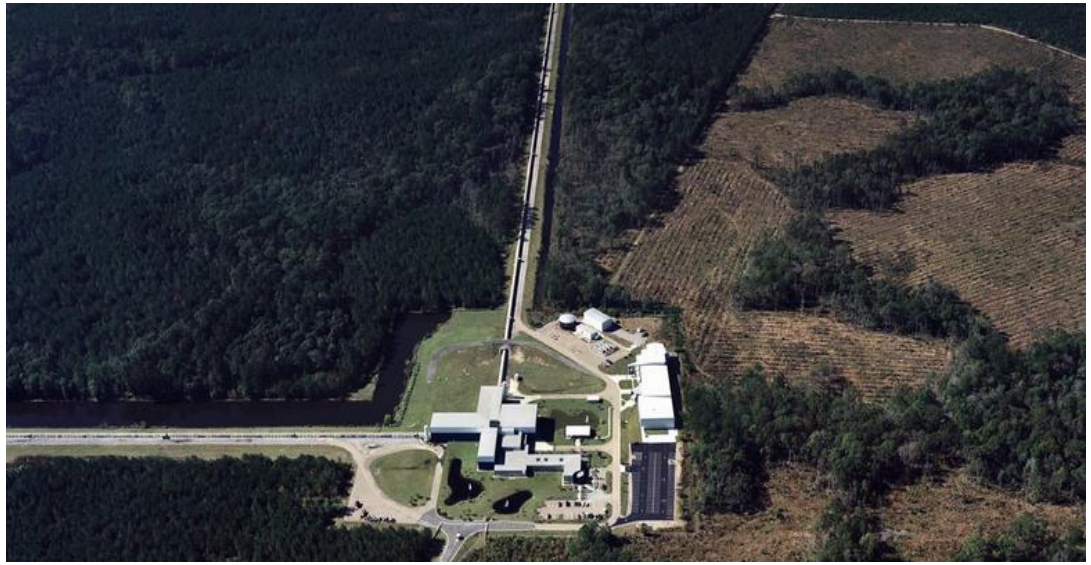


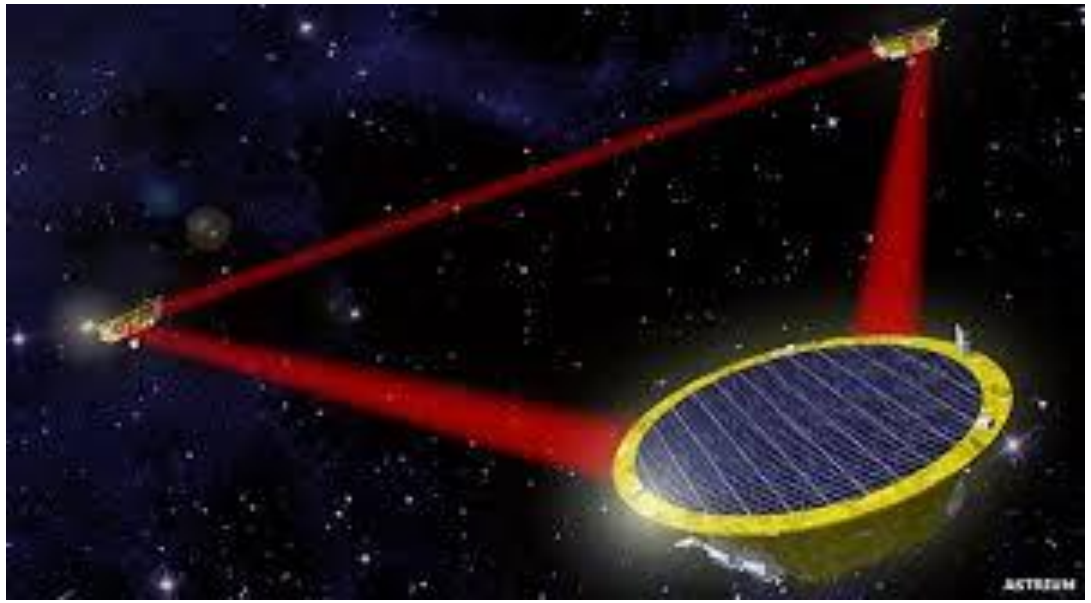
http://www.ast.cam.ac.uk/research/cosmology.and.fundamental.physics/gravitational.waves

Example of the spacetimes of an EMRI
(not to scale)



https://www.ligo.caltech.edu/LA/system/slides/binaries/4/slide_large_image/aerial_ligo5_300v4.jpg?1456255592

LIGO facility in Livingston, Louisiana



https://esist.tech/2017/06/21/lisa-is-on-gravitational-wave-detection-is-going-to-space/

Proposed Laser Interferometer Space Antenna (LISA)

COMPUTATIONAL ISSUES FOR EMRI(S)

- Short scale of spacetime distortion by stellar mass black hole
- Large length scale of supermassive black hole
- Long time evolutions

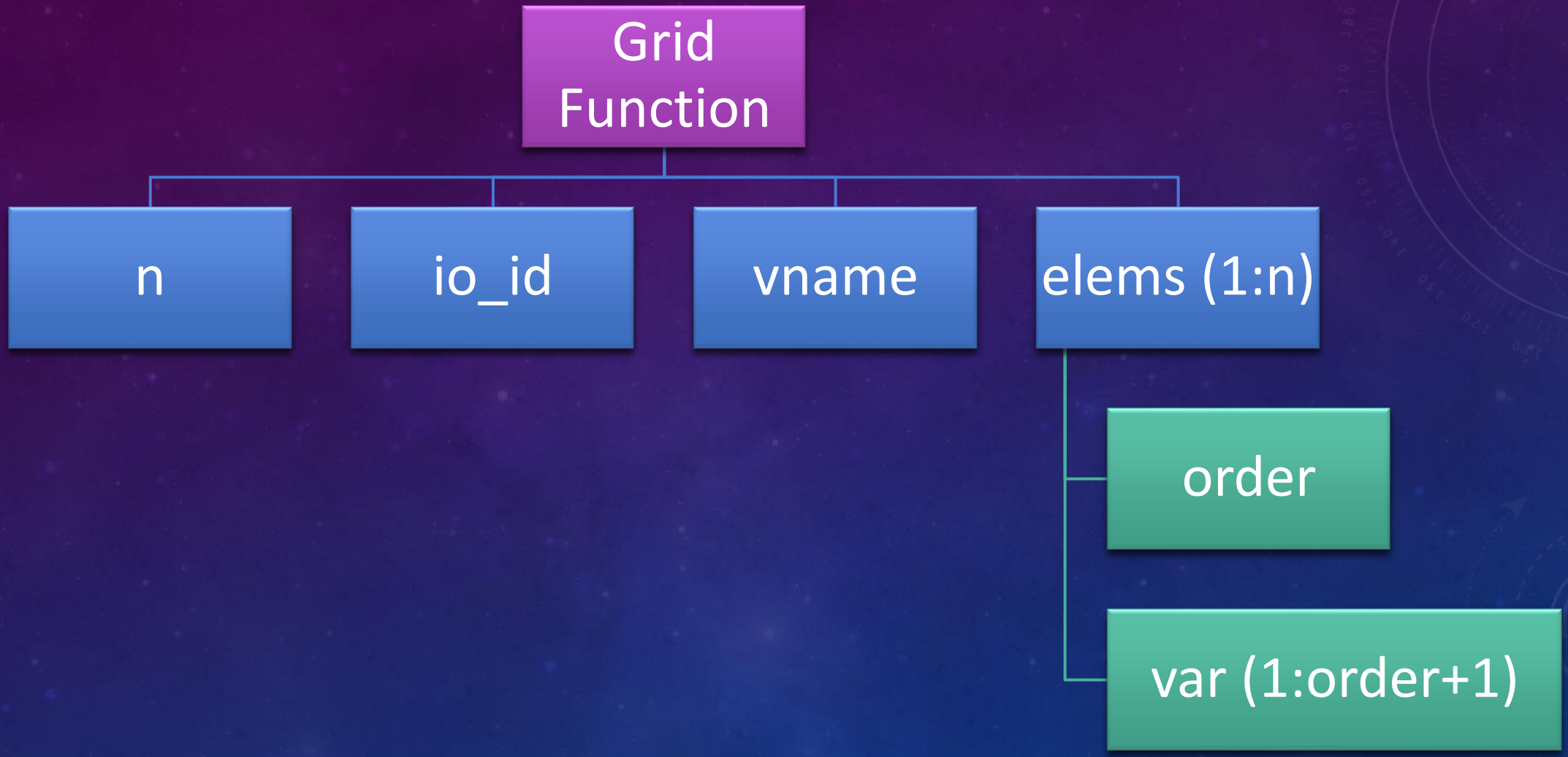
SELF FORCE IN 1-DIMENSION

- Created by Dr. Peter Diener et al.
- Uses perturbative theory
- PDE's broken down into (1+1) dimensional evolution using spherical harmonics
- Has a self-consistent evolution: the field and orbit of the particle evolve at the same time

```
module grid_function
!! Module that defines the concept of a grid function and the interface of the
!! associated routines.
!!
!! The implementation is found in
!! [[submodule_grid_function_implementation.f90]].
  use kinds
  use element

  implicit none

  type, abstract :: gf
  !! An abstract grid function class.
    integer(ip) :: n
    !! The number of elements.
    character(:), allocatable :: vname
    !! The name of the grid function.
    integer(ip) :: io_id
    !! The file unit used for output of this grid function.
  end type gf

  type, extends(gf) :: rgf
  !! A real data instance of the abstract grid function class. Note this is
  !! not complete, as it has not been needed for evolution yet.
    type(element_rdata), dimension(:), allocatable :: elems
    !! A 1d array of the real element data class.
    contains
      procedure, non_overridable :: output => output_rgf
      !! Generic type bound procedure for output.
```

CHECKPOINTING RESTART FACILITY

- Use hdf5-hierarchical data format version 5
- Parameters and Grid Functions
- Implement in existing code


Grid Function
n
io_id
vname
elems (1:n)
order
var (1:order+1)

```
HDF5 "checkpoint.1.h5" {
GROUP "/" {
   DATASET "Grid Function" {
      DATATYPE  H5T_COMPOUND {
         H5T_STD_I32LE "n";
         H5T_STD_I32LE "io_id";
         H5T_STRING {
            STRSIZE 1;
            STRPAD H5T_STR_SPACEPAD;
            CSET H5T_CSET_ASCII;
            CTYPE H5T_C_S1;
         } "vname";
         H5T_VLEN { H5T_COMPOUND {
            H5T_STD_I32LE "order";
            H5T_VLEN { H5T_IEEE_F64LE} "var";
         }} "elems";
      }
      DATASPACE  SIMPLE { ( 1 ) / ( 1 ) }
      DATA {
      (0): {
            3,
            -1,
            "\004",
            ({
                  2,
                  (11, 10, 9)
               }, {
                  2,
                  (12, 11, 10)
               }, {
                  2,
                  (13, 12, 11)
               })
      }
```

CURRENT STATUS

- Saved grid function
- Saved single parameters

FUTURE WORK

Determine what the checkpoint file needs

Read back into code and test

Expand code to include Kerr spacetime

(Sho Gibbs of LSU Physics REU)

Thank you

Questions?