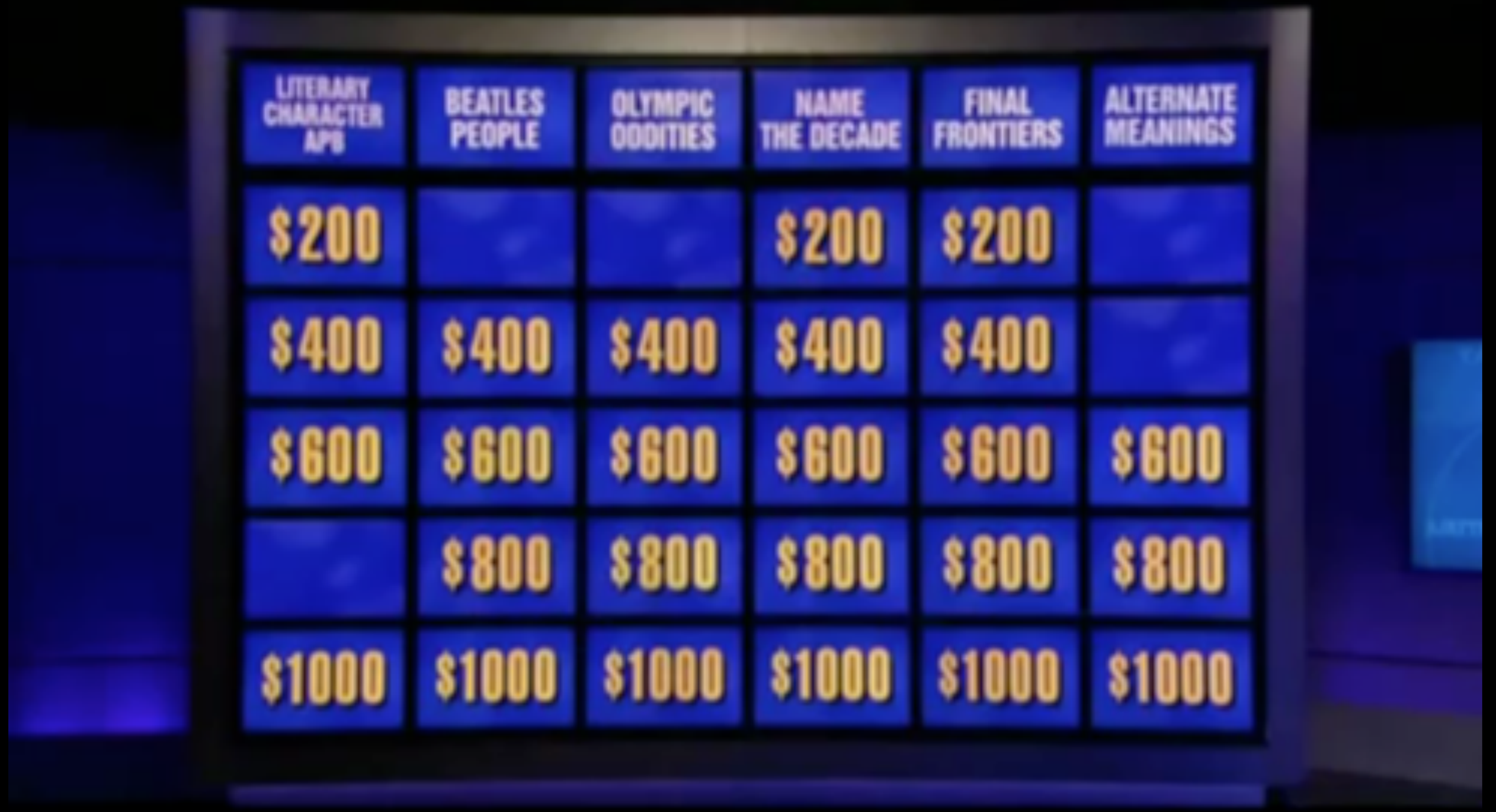
Day 3

- Gravitational-wave concepts (with Dr. Gabe Bonilla)
- Unix activity
- (Choose one head-on collision on binary black holes and start the calculation)
- Parallelize pi dartboard

Gravitational waves intro

- Dr. Gabe Bonilla: a postdoctoral researcher in our center


IBM
IBM
POWER7
POWER7
POWER7


LITERARY CHARACTER APB
BEATLES PEOPLE
OLYMPIC ODDITIES
NAME THE DECADE
FINAL FRONTIERS
ALTERNATE MEANINGS
$200
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Connect to ocean

- Open cocalc
- Open a new terminal
- ssh ocean
- Passphrase: see whiteboard

Unix commands to know

- **Commands to know**
  - ls, pwd, cd, mkdir
  - ./, ../, paths
  - **cp, mv, rm, rmdir**
  - cat, **less**
  - nano
  - **whoami, date, …**

- **Play along…**

Clicker question #1.8

- I want to list the files in the directory I’m in. Which command would I use?

A ls

B cd

C pwd

D nano

Clicker question #1.9

- Which command edits the file “Hello.txt” in the directory I am currently in?

A nano ./Hello.txt

B cat ./Hello.txt

C nano ../Hello.txt

D cat ../Hello.txt

Clicker question #1.9

- Which command makes a new directory called “TestFolder”?

A ls TestFolder

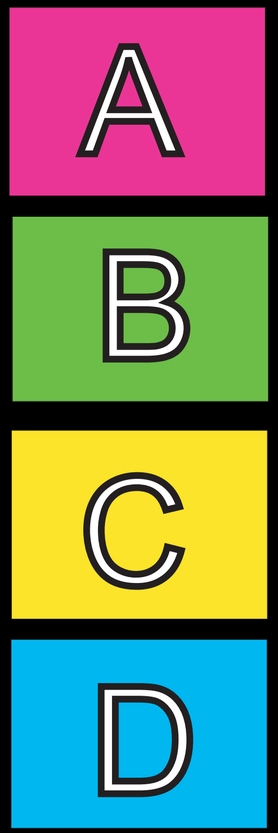
B cd TestFolder

C mkdir TestFolder

D cp TestFolder

Clicker question #1.9

- Which command removes everything in the current directory, which is not empty?



rmdir ./

rm -r ./*

rm -r . /*

More than one of these will work

Start your own simulation of merging black holes

- Start from rest, collide head-on
- Choose mass ratio between 1 and 1.2
- Choose spin = 0,0,0 on the smaller black hole (B)
- Choose spin = 0,0,X on the larger black hole (A), where X is between 0 and 0.2
- Set Omega0 = 0, adot0=0, D0=35

```
cd $HOME
cd StudentFolders
cd YOURNAME # replace YOURNAME with the name of your folder
```

```
cd $HOME
cd StudentFolders
cd YOURNAME # replace YOURNAME with the name of your folder
mkdir BlackHoleMerger
cd BlackHoleMerger
```

```
cd $HOME
cd StudentFolders
cd YOURNAME # replace YOURNAME with the name of your folder
mkdir BlackHoleMerger
cd BlackHoleMerger
source $HOME/spec/MakefileRules/this_machine.env
```

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cd $HOME
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PrepareID -t bbh2 -no-reduce-ecc
```

Spacetime
Visualizing with diagrams

- Set of points, but each point is an event
  - Event = a specific place at a specific time
    - 3 dimensions of space + 1 dimension of time

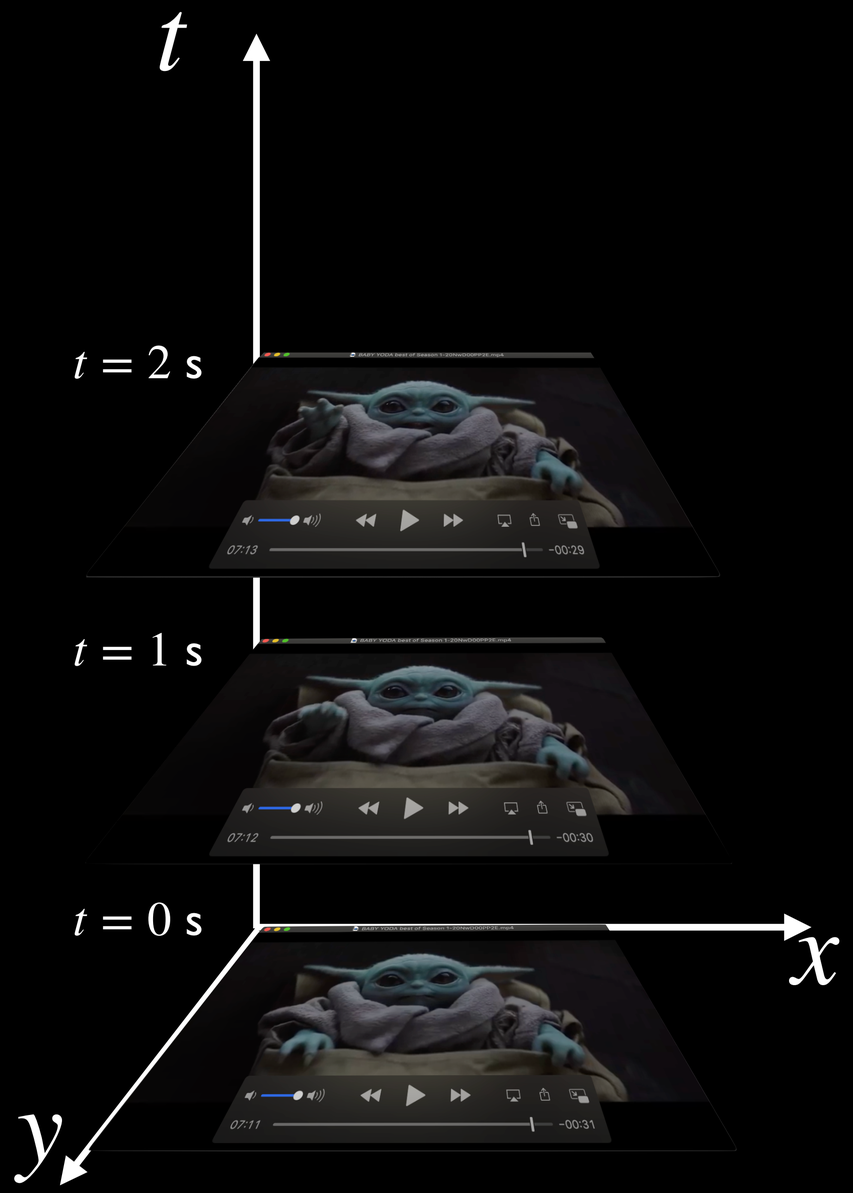

Image & movie courtesy Disney / *The Mandalorian*

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PrepareID -t bbh2 -no-reduce-ecc
nano Params.input
# Omega0 = 0.0
# adot0 = 0.0
# D0 = 35.0
# MassRatio = 1.2 #or 1.0, or something in between
# @SpinA = (0.0, 0.0, 0.0) #can make 1 component up to 0.2 instead
of 0.1
# @SpinB = (0.0, 0.0, 0.0)
```

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nano Ev/DoMultipleRuns.input
# my MaxLev = 1
```

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source $HOME/spec/MakefileRules/this_machine.env
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of 0.1
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nano Ev/DoMultipleRuns.input
# my MaxLev = 1
./StartJob.sh
```

```
squeue
scontrol show jobid -dd YOUR_JOB_ID
ShowQueue
```

Parallel computing

- Supercomputers have lots of cores
- But each core is not much faster than a PC
- To take full advantage, you have to write code that can run on more than one core at the same time
- That is, code that runs in parallel

Image courtesy Blue Waters

Parallel computing 1

- Log into cocalc
- In a terminal:

```
#ReplaceYourName with your name
ssh ws2021@ocean.fullerton.edu
cd StudentFolders
mkdir YourName
cd YourName

mkdir PiDart
cd PiDart
```

Parallel computing 2

- # In your terminal, make a file "Hello.py" and put the following Python code into it
- nano Hello.py

```
print(“Hello")
```

- mpirun -np 8 python Hello.py
- **What happens? What happens if you change 8 to another number less than 8?**

What happened?

- mpirun ran many copies of “Hello.py”
- Each copy printed “Hello”
  - But the processors are not working together yet, or even doing anything different
- Next: make different processors do different things

Parallel computing 3

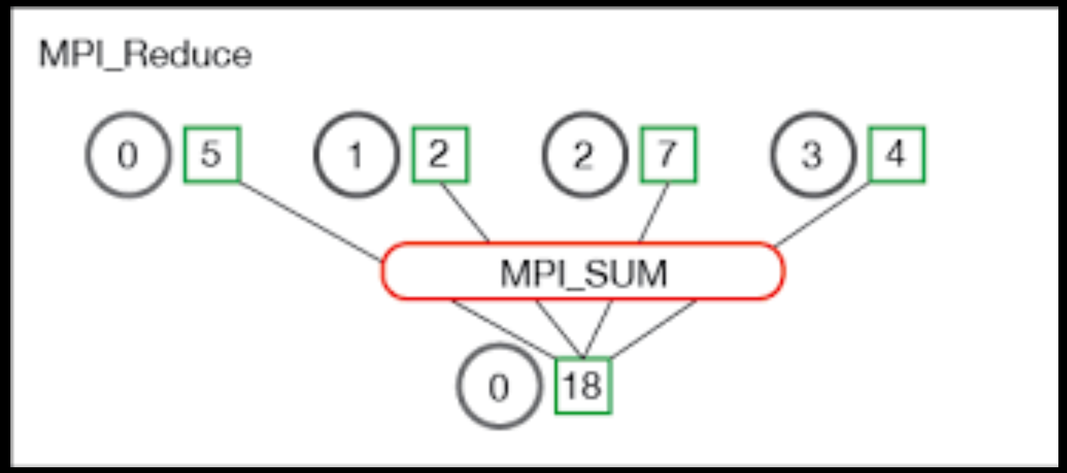
- cp Hello.py MpiHello.py
- nano MpiHello.py

```
from mpi4py import MPI
comm = MPI.COMM_WORLD
rank = comm.Get_rank()
size = comm.Get_size()
print("Hello from processor "+str(rank)+" out of
"+str(size))
```

- mpirun -np 4 python MpiHello.py
- mpirun -np 8 python MpiHello.py

Paralleizing the dartboard

- **What if we combined results from the whole class's π dartboard?**
- **Even batter**
  - Run lots of copies of the dartboard on lots of cores
  - At the end, each copy tells the others how many hits it had
  - Each copy adds up the number of hits on all processors and computes pi



Parallelizing the dartboard 2

- cp /home/workshopStudent2018/SharedStuff/Tuesday/piEstimate.py .
- nano piEstimate.py
- #Add the same mpi4py lines at the top

```
from mpi4py import MPI
comm = MPI.COMM_WORLD
rank = comm.Get_rank()
size = comm.Get_size()
```

Parallelizing the dartboard 3

- nano PiDart.py
- #At the bottom, instead of getting pi, print the number of hits on each processor

```
print(str(hits)+" hits on processor "+str(rank)+" out of "+str(int(throws))+" throws.")
```

- mpirun -np 12 python piEstimate.py
  - What happens?

```
from mpi4py import MPI
comm = MPI.COMM_WORLD
rank = comm.Get_rank()
size = comm.Get_size()
```

Parallelizing the dartboard 4

- nano piEstimate.py
- #Divide the darts to throw among the processors, instead of each processor throwing the total

```
hits = 0
throws = 1e7 // size
i = 0
while i < throws:
# … rest of program
```

- mpirun -np 12 python piEstimate.py
  - What happens?

Parallelizing the dartboard 5

- nano piEstimate.py
- #Have on processor add up the totals across all processors

```
print(str(hits)+" hits on processor "+str(rank)+" out of "+str(throws)+" throws.”)
```

```
throwsAllProcessors = throws * size
hitsAllProcessors = comm.allreduce(hits, op=MPI.SUM)
```

```
if rank == 0:
    print(str(hitsAllProcessors)+" hits on all processors, with "+str(throwsAllProcessors)+" throws.")
```

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Parallelizing the dartboard 6

- nano piEstimate.py
- #Compute pi

```
if rank == 0:
    print(str(hitsAllProcessors)+" hits on all processors, with "+str(throwsAllProcessors)+" throws.”)

    pi = 4.0 * float(hitsAllProcessors) / float(throwsAllProcessors)
    print(pi)
```

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