Astronomy 596/496 APA
Lecture 1
Aug. 27, 2015

Announcements:

- Welcome!
- Pick up Syllabus
- Homework 1 due at start of class next time, Sept. 3

Today's Agenda

★ Introductions

★ Motivation and Preview

★ Introduction to the Art of Estimation

Introductions

Motivation and Preview

Why this course?

You are here to learn how to become researchers:
astronomers, astrophysicists, cosmologists

We want to get you up to speed, and prepare you
for the next steps

Formal courses expose you to
data, theories, formalism, analytical tools
$\rightarrow$ all crucial for research

But to live long and prosper in the *art* and *practice* of astronomy
involves much more:

- science: unwritten/informal research tools
- "sociology": unwritten expectations, opportunities, challenges

We want Illinois students to have every advantage
when you go forth into the wide world of astro-research

...and so...

this is our attempt to give you
an "unfair advantage"...

ASTR 596/496 APA: The Facts of Astrophysical Life

Everything you ever wanted to know
but were (maybe) afraid to ask

Goals

★ learn how to live, thrive, and survive in astronomy/astrophysics/cosmology

★ become familiar with unwritten rules, tools, and expectations

★ gain awareness of career paths, milestones, opportunities, challenges

Strategy

★ learn by doing

▷ order-of-magnitude estimation

▷ map out career milestones, key documents

★ knowledge is power

▷ estimation skills drive research, impress colleagues/employers

▷ career information allows decisions and planning

The Bargain

This course is unusual: it is
experimental, *informal*, and *interactive*
⇒ successful experiments require
dedicated and patient experimentalists: *all of us!*

Instructors we will
- give unvarnished truth as we see it,
- be respectful of your participation
- be responsive to your interests, questions, and suggestions

Students you should *own* this course
- **participate** and be **interactive**
  attention and engagement are essential; *correct answers aren't*
- respect others and their contributions

Course Structure

Your time–in class and in homework–will be divided roughly equally between

⋆ Order-of-Magnitude Estimation

and

⋆ Career Paths and Research Skills

The Purpose of Graduate School

Q: what is the main purpose of graduate school?

Q: what observable evidence shows progress towards this goal?

The Purpose of Graduate School: Research

A graduate degree is training to do **research**

- research requires a wide skill set
- we don't expect you to have all of these skills yet
- look for opportunities to develop, practice, master these skills

Observable evidence = Research Output

⋆ **Refereed Publications with you as first author!**

- talks you give about your research

Benefits flow from publication:

- fellowships, talk invites, postdocs, observing/computer time
- and cash! Astro Dept rewards grad 1st-author pubs with $100

Thus: Plan grad career around writing papers

Career Paths: Surveying the Phase Space

a degree in Astronomy/Astrophysics is
⋆ valued
⋆ versatile

Astrophysicists are in a wide array of careers
Profs at Illinois: academia, reasearch-1 university

full phase space is much larger!

To give a broader idea of possibilities:
Guest Speakers: Illinois Grad and Undergrad alums
- once literally sat in your chairs
- can tell you how they got where they are

anticipated or confirmed speakers:
aerospace, data science, national labs, other?

Syllabus

Introduction to the Art of Estimation

Why estimation?

You've taken many courses and spent a lot of time
learning complex and powerful tools for precise calculations
You've heard about "precision cosmology"

Isn't this course a step backwards?
Maybe: *Those who can't calculate, they approximate!*

After all you've done to do things the hard way
and the precise way
Q: why learn to make rough, imprecise approximations?

Approximation is Real Science

the real world is subtle and rich (≡ complicated)
physics/astro phenomena elaborately detailed, but
not all details equally important

no real-world system *ever* simple enough
to calculate without *any* approximation
and even if you could, complicated result hides insight

faced with a new problem: simplify!
...but keep the essentials

approximations and estimates help you
- to see what is relevant
- to see what is irrelevant
- to test ideas/hunches quickly

★ identify which detailed calculation(s) are worth doing

Fermi Problems

Enrico Fermi famous for his estimation skills
"Fermi problems" – rough calculations to get insight
famous/notorious legend: paper scraps at Trinity test

Fermi Canonical Example

Estimate the number of piano tuners in Chicago

Modified Example

Estimate the number of pizza parlor in Chicagoland

Fermi Problems

Estimate the number of pizza parlor in Chicagoland

The Game

- make educated/uneducated guesses
- estimate answer as well as uncertainty in answer
- don't look up any numbers until checking answers

Strategies

more than one way to approach this

Q: think of at least two!

Chicago Pizza Parlors

Strategy 1: Guess

to within an *order of magnitude*, what *smells* right?

i.e., for $N_{\text{pizza}}^{\text{Chi}} \sim 10^x$, guess x

and if $x = n$ seems low, and $x = n + 1$ seems high,

try $x = n + 1/2$, i.e., $10^{n+1/2} \approx 3 \times 10^n$

$N_{\text{pizza}}^{\text{Chi}} \sim 1,\ 3,\ 10,\ 30,\ 100,\ \ldots?$

Q: your guess?

Notation for Approximation:

$a \propto b$: proportionality (units differ)

$a \sim b$: good to within about 10^1 (units same)

$a \simeq b$: good to within about a factor 2 (units same)

Note: not a sharp division between the last two, and

people sometimes use other conventions

Chicago Pizza Parlors

Strategy 2: Divide and Conquer

break big problem into small pieces you know how to solve

e.g., maybe begin with: How many people live in Chicagoland?

Note:

- more than one way to do this
- each factor has uncertainties, but if you are honest overestimates might cancel underestimates
- famous example: Drake equation

Q: procedures?

Q: expected accuracy of answer?

Chicago Pizza Parlors

Check your answer!

Q: What's the best way to do this with the internet?

Compare real vs estimated answer and accuracy

Q: What lessons do we draw?

Colloquia

You should go!

Q: Why?

Q: Why is it hard at first?

Colloquium Preview

Astrophysics Colloquium: Tuesdays, Here, 3:45-4:45

Next week, Sept. 3

- Eric Morganson, U Illlinois, DES Research Scientist
- "Mapping the Outer Milky Way with Optical Surveys: Is there a Giant Donut Around Our Galaxy?"

Q: optical?

Q: surveys?

Q: Outer Milky Way?

Q: What could create a donut? (mmmmmm, donuts...)