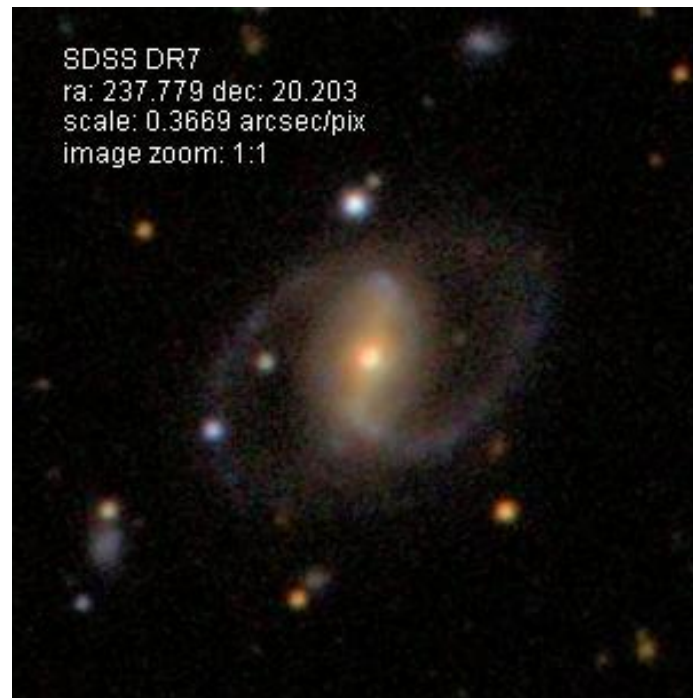# The Chandra – Zoo Project: Morphological Galaxy Classification

Gregory Minutillo

Why Observe Galaxies?

- Clues to their origin/formation/ evolution of galaxies can be revealed

- Better understanding of our own Milky Way galaxy
  - Foreshadowing: classified as a spiral, bar, small bulge prom

Andromeda: Milky Way's big sister

The Sloan Digital Sky Survey (SDSS)

- Robotic telescope surveying the sky recording over millions of galaxies
- Give a representation of the universe that is 100x the volume than that explored to date.
  - Problem: no computer can classify galaxies as well as the human eye
  - Idea: The Galaxy Zoo project
    - Everyday people (citizen scientists) can learn how to classify galaxies
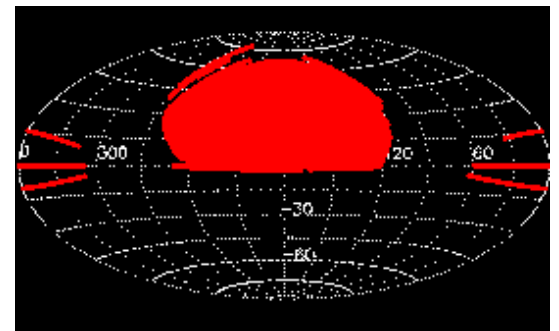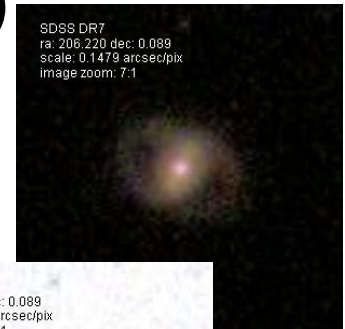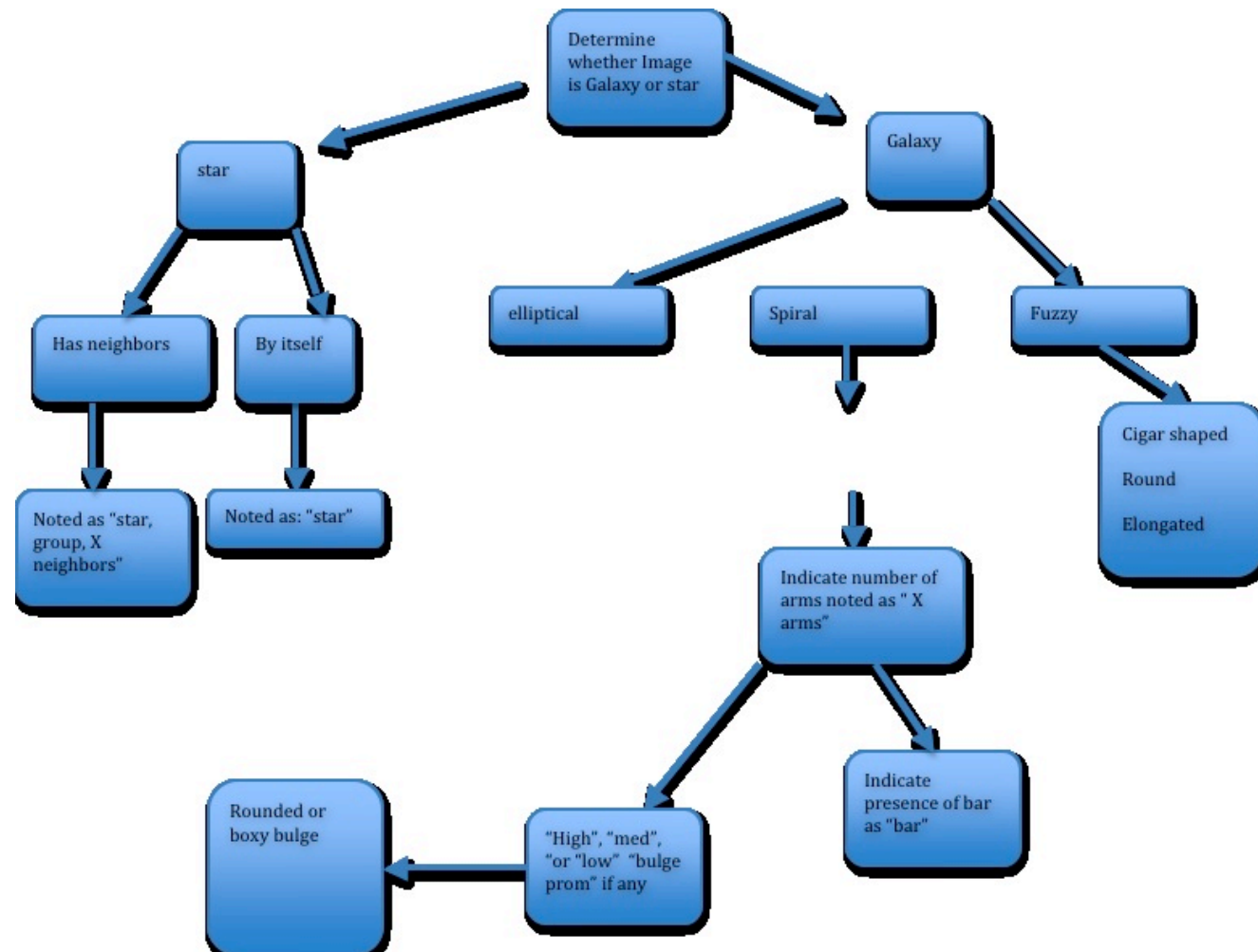
Can Everyday People Do This?

- YES!
  - Eg. Me
- The information needed by astronomers can be derived from analyzing the statistical sample of classifications.
  - Eg. Galaxy Zoo 1 devoted mainly to divide spirals and ellipticals
    - If 990 participants say it's elliptical, and 10 say its irregular, and 7 say elongated, It's probably elliptical.
    - Classification test
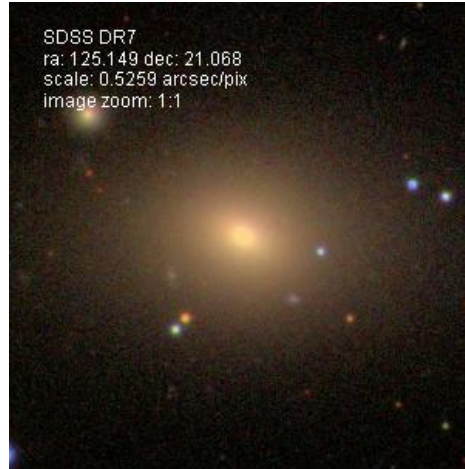
Classification: The Chandra-Zoo Project

- Database of galaxies ~600
  - SDSS objects for which we have Chandra X-ray data.
  - Optical vs. X-Ray (complementary)
- Once, twice, three times?
  - Images with regular colors
  - Images with color inversions
  - You?
- The Decision Tree:

Decision Tree:

Ellipitical

SDSS DR7
ra: 170.610 dec: 24.299
scale: 0.4636 arcsec/pix
image zoom: 1:1

SDSS DR7
ra: 125.149 dec: 21.068
scale: 0.5259 arcsec/pix
image zoom: 1:1

SDSS DR7
ra: 167.435 dec: 21.759
scale: 0.4665 arcsec/pix
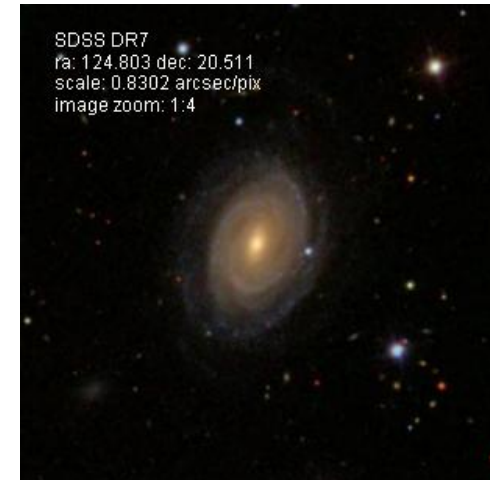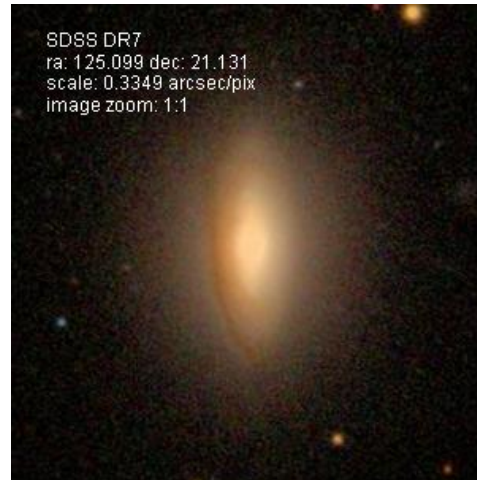image zoom: 1:1

*with neighbors

Criteria:
- The whole galaxy looks like a ball/bulge.
- Star/luminous matter must appear to be revolving in ellipses (Hence: the name)

Easier to distinguish when the images are clear

Spiral Galaxies: Arms, Rotation, and Bulges
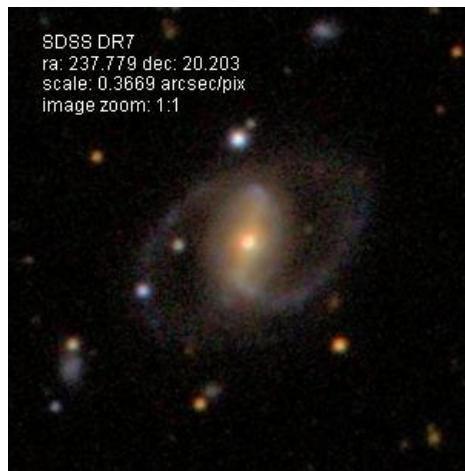
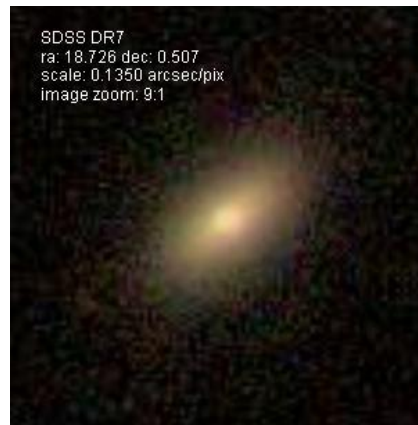"spiral, cw, 2 arms, bar, med bulge prom"

"spiral, cw, 3 arms, med bulge prom"

Difficulties:
- Number or arms is hard to determine for some, especially tight spirals.
- Bulge prominence is subjective
  - It's in terms of brightness (low, med, high)

Rounded, Elongated, Cigar

SDSS DR7
ra: 207.280 dec: 5.070
scale: 0.1393 arcsec/pix
image zoom: 8:1

SDSS DR7
ra: 18.726 dec: 0.507
scale: 0.1350 arcsec/pix
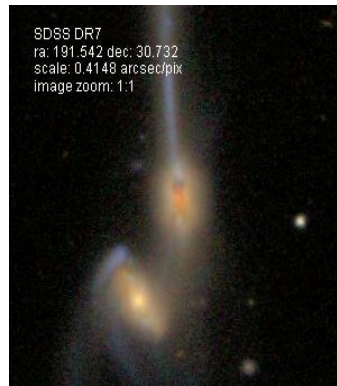image zoom: 9:1

SDSS DR7
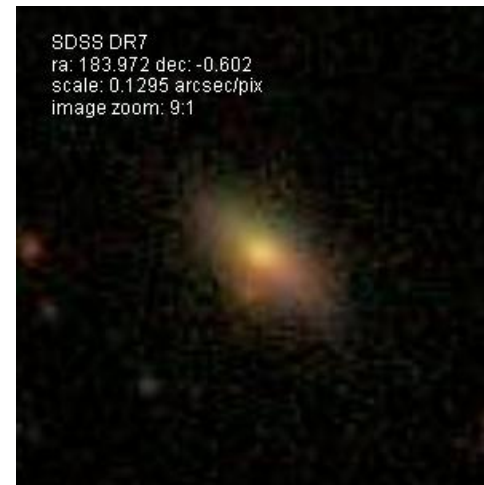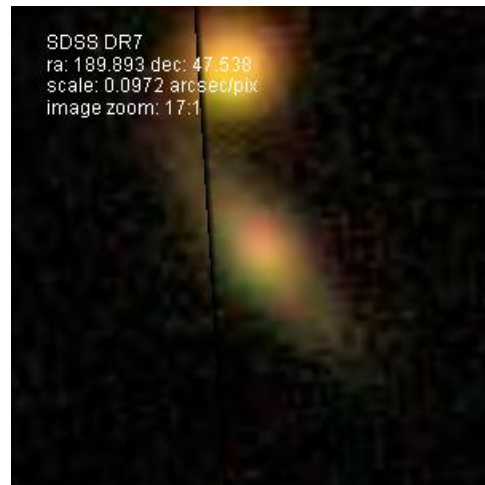ra: 170.661 dec: 1.060
scale: 0.1424 arcsec/pix
image zoom: 8:1

Desperate attempt to extract information!

The Difficulties Arise

Not necessarily in these (irregular and/or interacting)…

But in distinguishing between these (disc or just fuzzy and elongated)

You Try

SDSS DR7
ra: 189.423 dec: 26.710
scale: 0.4326 arcsec/pix
image zoom: 1:1

SDSS DR7
ra: 177.264 dec: 22.411
scale: 0.2955 arcsec/pix
image zoom: 2:1

SDSS DR7
ra: 183.854 dec: 26.537
scale: 0.1786 arcsec/pix
image zoom: 5:1

SDSS DR7
ra: 136.911 dec: 16.593
scale: 0.1498 arcsec/pix
image zoom: 7:1

SDSS DR7
ra: 209.011 dec: 18.372
scale: 0.3172 arcsec/pix
image zoom: 2:1

SDSS DR7
ra: 125.886 dec: 21.338
scale: 0.2743 arcsec/pix
image zoom: 2:1