Astro 210

Lecture 27

October 27, 2010

Announcements

- Hour Exam 2 next time
- similar setup, format, as last exam
- `www: exam info page`

Last time: exoplanets

detection methods

- reflex motion *Q: what's that? what does it tell you?*

  `www: simulations, data`

  what doesn't it tell you?
- transits *Q: what are they? what do they tell you?*

  `www: data`

results so far

Q: planet properties? orbital properties?

iClicker Poll: Exoplanet Non-Surprises

Of the following properties of exoplanets
discovered by techniques available to date...
which should **not** come as a surprise?
that is, couldn't have been any other way

A most exoplanet masses are large: $M \approx M_{\text{Jupiter}}$

B many exoplanets observed with large eccentricities $e > 0.2$

C exoplanet semimajor axes not too large: $a \leq 6$ AU

Exoplanets: Trends and Mysteries

No Surprise: new planets are massive
$\Rightarrow$ needed to get big, observable velocity wobble
if not massive, could not have found!
selection effect: doesn't prove all planets massive
since couldn't find low mass with this technique
$\rightarrow$ largeness of detected mass is statement about detection method,
not about planet properties

Big Surprise: very short periods found
$\rightarrow$ planets are **very** near stars!
ex: τ Boo is 3.6 $\times$ Jupiter mass,
but closer than Mercury's orbit!
nothing like our Jovian planets! "hot Jupiters"

`www: exoplanet fraction vs heavy element content of host star`
Q: what does this mean?

Exoplanet Trends Continued

Role of heavy elements

- planets more common around stars with high levels of heavy elements ("metals")

$\rightarrow$ clues to formation...

Multiple-Planet Systems

- dozens multiple-planet systems seen thus far

Planet Sizes

- in transiting systems can find planet size around that of Jovian planets $\rightarrow$ density $<$ rocky, iron

  $\rightarrow$ these are gas giants, not terrestrial!

Exoplanet Trends Continued

Masses

more massive planets easier to find
  larger star reflex motions, larger transit eclipses
$\Rightarrow$ first discoveries all Jupiter mass or more
but as techniques have improved,detect smaller masses
many Saturn-mass, Neptune-mass objects found
to date, recordholding low mass: $4.10 M_{\text{earth}}$
  with controversial claims of $1.94 M_{\text{earth}}$

Atmospheres

atmospheres detected for a few planets
$\rightarrow$ only possible for close-in giants in transiting systems
Q: how would this work?
results:

- "hot Jupiters" have gaseous atmospheres
- hydrogen, water vapor, sodium detected
- evidence for clouds, atmospheric circulation!

The Habitable Zone

habitable zone defined as:
region around a star
  where planets can contain liquid water
Q: is this a reasonable definition? alternatives?

this month–candidate habitable zone planet: Gleise 581g
host star is not solar like, but low-mass "M dwarf"
5th planet found around star, via reflex motion
  have to subtract wobble effects of other planets
but even more recently: competing group redid subtraction
  not assuming circular orbits, no evidence for GL 581g!

Q: lessons?

Exoplanet Statistics

after searching nearby stars, can compare:
stars with planets found via reflex motion
vs total stars searched
ratio gives fraction/percentage of planet-bearing systems

Results

⋆ about $\approx 10\%$ of solar-type stars
have planets of masses (0.3 to 10)M_{Jupiter}
and orbital period $P = 2 - 2000$ days

⋆ extrapolation of observed trends suggests
about $\approx 20\%$ of stars have gas giants at $a \leq 30$ AU

Q: what does this tell us? not tell us? possible biases?

∞

Q: what does all of this mean for solar nebula theory?

Extra-Solar Planets: Implications

Solar Nebla theory: giant planets born far from star
Data: Giant exoplanets found very close
$\Rightarrow$ Theory is incomplete/wrong!

New Planets, New Questions:

1. Who is normal: them or us?
e.g., maybe SS is common, but
others more likely to be found by this technique
Note: current techniques can only now see Jupiter around
nearby star using this method

2. What's up with the very close orbits?

Maybe some giant planets born close in?

Q: why would this be surprising?

Maybe some giant planets be born far, move in?

`www: planet eating sketch`

if so: what stops them from falling into star?

3. How to get large eccentricity?

exoplanets show no preference for circular orbits

average exoplanet eccentricity $>$ *all* solar system planets!

Why no large e in SS?

Exoplanets: The Future

much excitement,
will play major role in Astrophysics in upcoming decade

just now operational:
`www: NASA Kepler` space mission,
precision monitoring of thousands of stars for transits
Q: why go to space to do this?
hundreds of candidate planets found already
  will take time to check for "false positives"
$\rightarrow$ major announcements expected soon

Anyway: planets common.
$\Rightarrow$ good news in search for life elsewhere...

Stay tuned!

Exam Review

www: First Page: Equation list

www: Sample Questions