Exoplanets in the far-IR?

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Exoplanets in the mid-infrared
a brief review....
Looking forward to JWST
Are the longest IR wavelengths useful?
Infrared astronomy began on the ground and required modulation techniques to detect the signal above the background. The eclipse of a transiting planet is *perfect* modulation.
First infrared light from exoplanets was detected using Spitzer.
A Surface Emission Map of an Exoplanet

Knutson, Charbonneau, et al. (2007)
Spitzer's Legacy (not that we're done..!)

photometric-resolution spectra for about a dozen planets in 4+ bands
(dozens more planets in the 3.6/4.5 microns bands)

*temperature structure, composition*

phase curves, spatial mapping, transit spectroscopy,
orbital dynamics, transit timing,
fluxes from super-Earths and more....
Spitzer results from a new analysis and Bayesian retrieval (HD149026b – a hot Saturn. Mike Line, UCSC)

need a uniform re-analysis of all Spitzer data, with new retrievals
Spitzer's measurement of a super-Earth

55 Cnc e  Demory et al. 2013
Tb = 2360 ± 300 K
The James Webb Space Telescope

6.5 m diameter
26 m² collecting area
0.7 - 25 microns
JWST (simulated) detection of carbon dioxide in a habitable SuperEarth

Deming et al. 2009
JWST should be able to measure carbon dioxide photometrically, in the thermal infrared.
Before Spitzer, the focus was merely on detection

But hot Jupiters to super-Earths *will* be detected by JWST. Instead, the principal issues are:

what can we learn about:
  atmospheric temperature structure..?
  molecular abundances..?
what are the best observing modes...?
Are there exoplanet applications at wavelengths longward of JWST....?

\[ \text{Watts m}^{-2} \text{ Hz}^{-1} \sim \Omega B_v \]

For planets, \( \Omega \) is small, but:
\( B_v \) is exponential in temperature at high frequency

But in the far-IR \( B_v \) is only \textit{linear} with temperature 
so planet flux may be negligible
(Radii about 5 $R_J$)

Marleau & Cumming, 2014
Sample calculation:

Protoplanet at 50 pc
2000 Kelvins and 5 $R_J$
30 and 100 microns
Absorption lines....
Spectral line sensitivity

log(protoplanet fluxes) at 30 & 100 are -29 and -30
Summary:

Spitzer leaves a rich legacy of exoplanet infrared measurements
  but we need to re-analyze the data uniformly and apply new Bayesian retrievals
JWST has myriad capabilities for exoplanet detection
  but we need modeling to identify the optimal observing modes
Exoplanets *per se* are too small for true far-IR observations
  *unless* there is unexpected physics, like masers