A catalog of waves
-or-
A systems approach to studying waves in the solar atmosphere

Lucas A. Tarr¹a, Tetsu Anan¹, Gianna Cauzzi¹, Valentin Pillet¹, Kevin Reardon¹, and Thomas Rimmele¹

¹National Solar Observatory, Boulder, CO and Maui, HI

altarr@nso.edu

Background image: https://www.etsy.com/shop/HiddenHale
Outline:

1. Wave ubiquity
2. Power dependence
3. Sources
4. Propagation
5. The global picture

Waves are everywhere!

Why? Because MHD equations are hyperbolic, so basically everything generates waves
Wave power varies with everything

Molnar + 2021 ApJ 920

Rajaguru +2013 SolPhys 287

Power vs Source depth: a) -35Mm, b) -30Mm, c) -20Mm – Khomenko+ 2009 AA
In addition to photospheric convective driving, there’s at least some wave emission in the corona.

Open Questions:

1. What waves are generated?
2. How much power do they have?
3. How often are they emitted?
Inhomogeneous atmosphere: Complicated and interesting wave propagation


Essentially a scattering process

In total, 70% conversion, 7% transmission, 23% dissipation

via
Srivastava+ 2021 JGR

Building a ‘system model’ for solar atmospheric wave mechanics

Wave Sources:
1. locations
2. temporal emission frequency
3. Power into each spatial/frequency/mode bin

Propagation Aspects
1. scattering locations
2. Ideal mode conversion
3. Coupling to partially-ionized modes
4. Interaction with “structured flux tubes”

Higher-level science questions
1. Dissipation (cascade, ion-neutral, phase mixing, shock)
2. Differential abundances (FIP effect -> solar wind)
3. Seismology

3D quasi-steady state
1. Topology
2. Density & Temperature

Observable properties
Phase speed, group speed and direction, phase relation between inferred quantities (intensity, temperature, velocity,...) all need 2 fluid treatment in photosphere and chromosphere; time-averaged vs “quasi-particle” analysis

Effect of adaptive optics/post-processing?