Spectroscopy: The Study of Squiggly Lines

[Astronomical Distances] [Basics of Light] [Tools for Light Analysis]
[Measuring Light] [Electromagnetic Spectrum] [Fun with Units]
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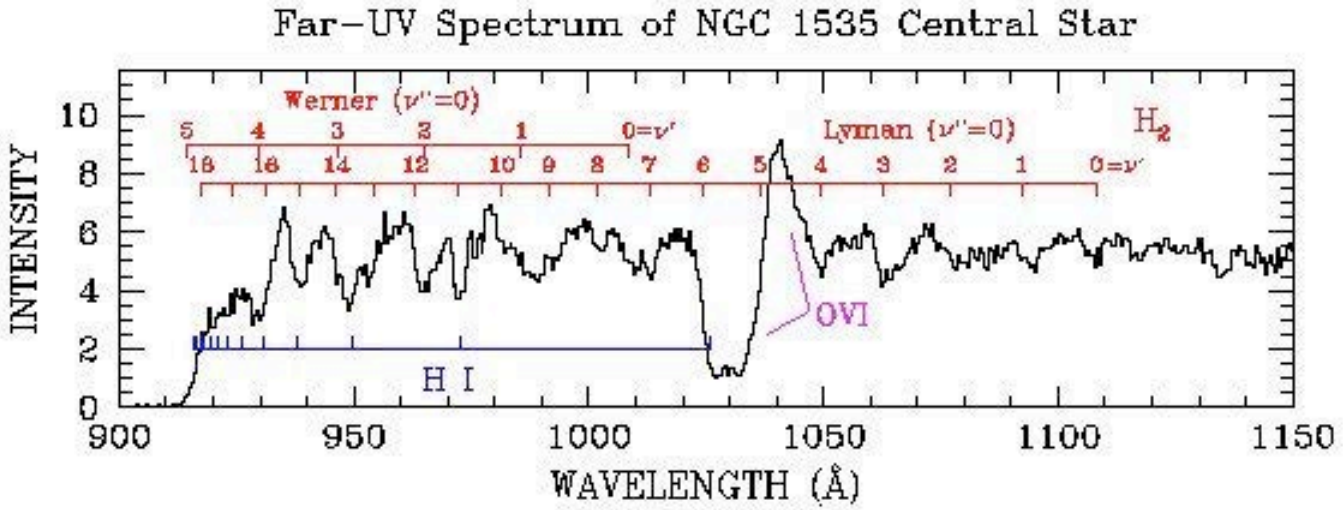
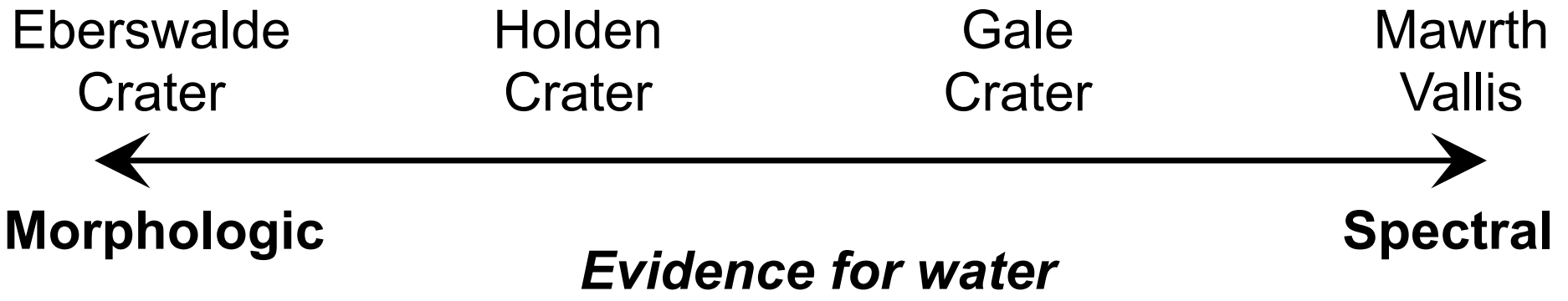
What are Those Squiggly Lines?

Using Light to Learn About the Universe



Spectroscopy in Curiosity's site selection



Interaction of Radiant Energy and Matter

What causes absorption features in spectra?

1) **Rotational absorption (gases)**

2) **Electronic absorption**

3) **Vibrational absorption**

Rotational Processes

Photons striking *free* molecules can cause them to rotate. The rotational states are quantized, so there are discrete photon energies that, when absorbed, cause the molecules to spin.

Rotational interactions are low-energy interactions and the absorption features are at long infrared wavelengths.

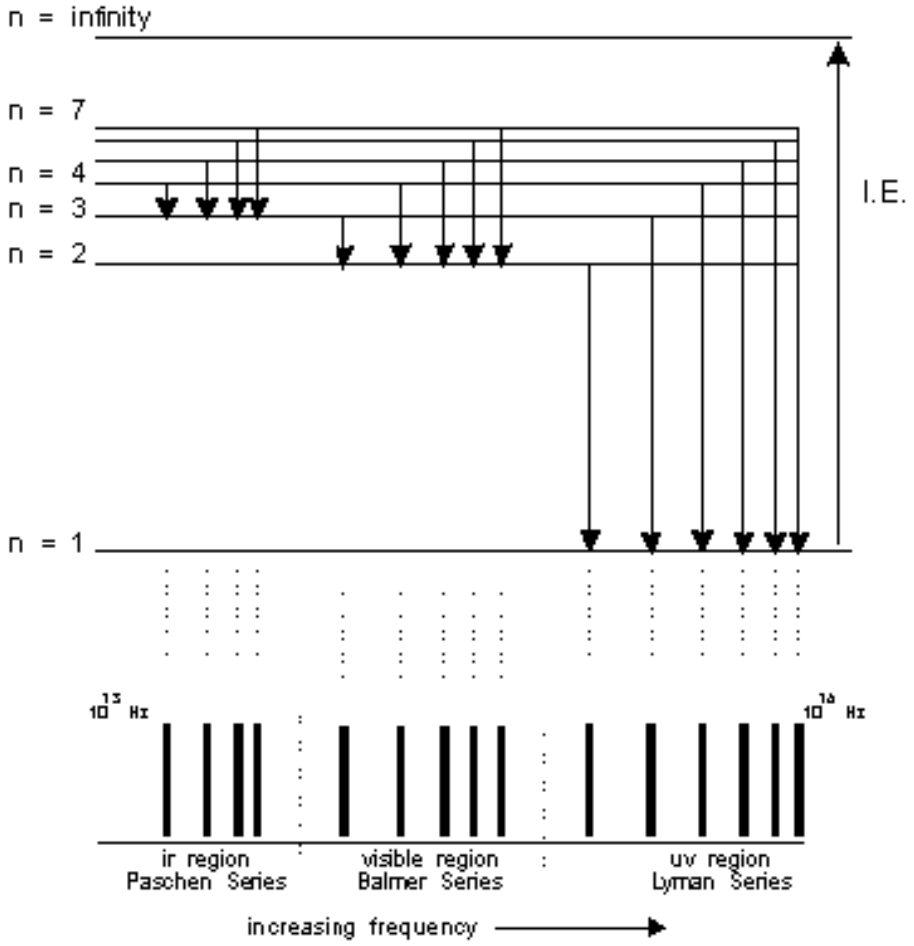
Not important in remote sensing of solid materials

Electronic Processes

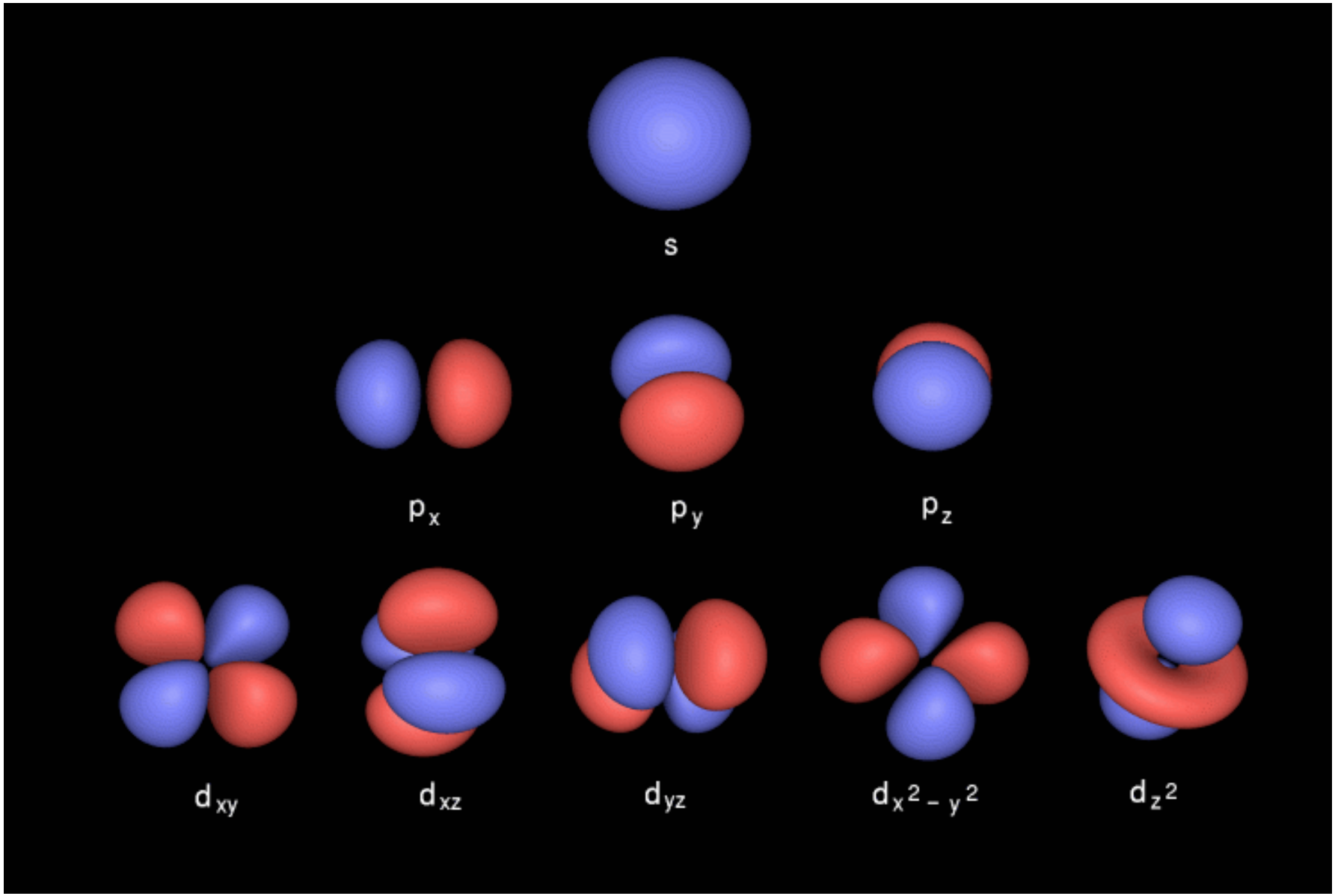
Isolated atoms and ions have discrete energy states. Absorption of photons of a specific wavelength causes a change from one energy state to a higher one.

In solids, four types:

- **Crystal Field Effects**
- **Charge Transfer Absorptions**
- **Conduction Bands**
- **Color Centers**



Electron Orbits

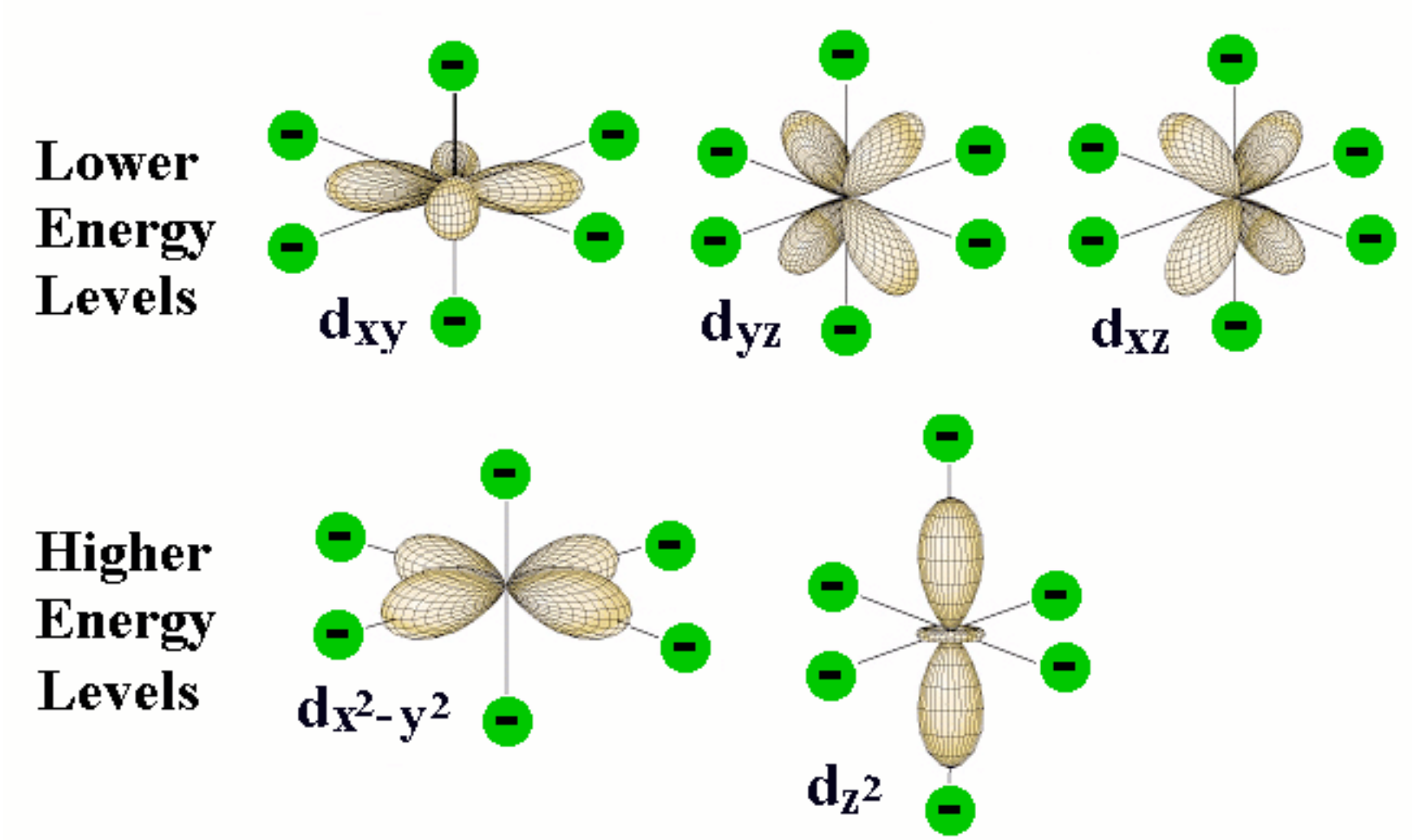


Electronic Processes

Crystal Field Effects

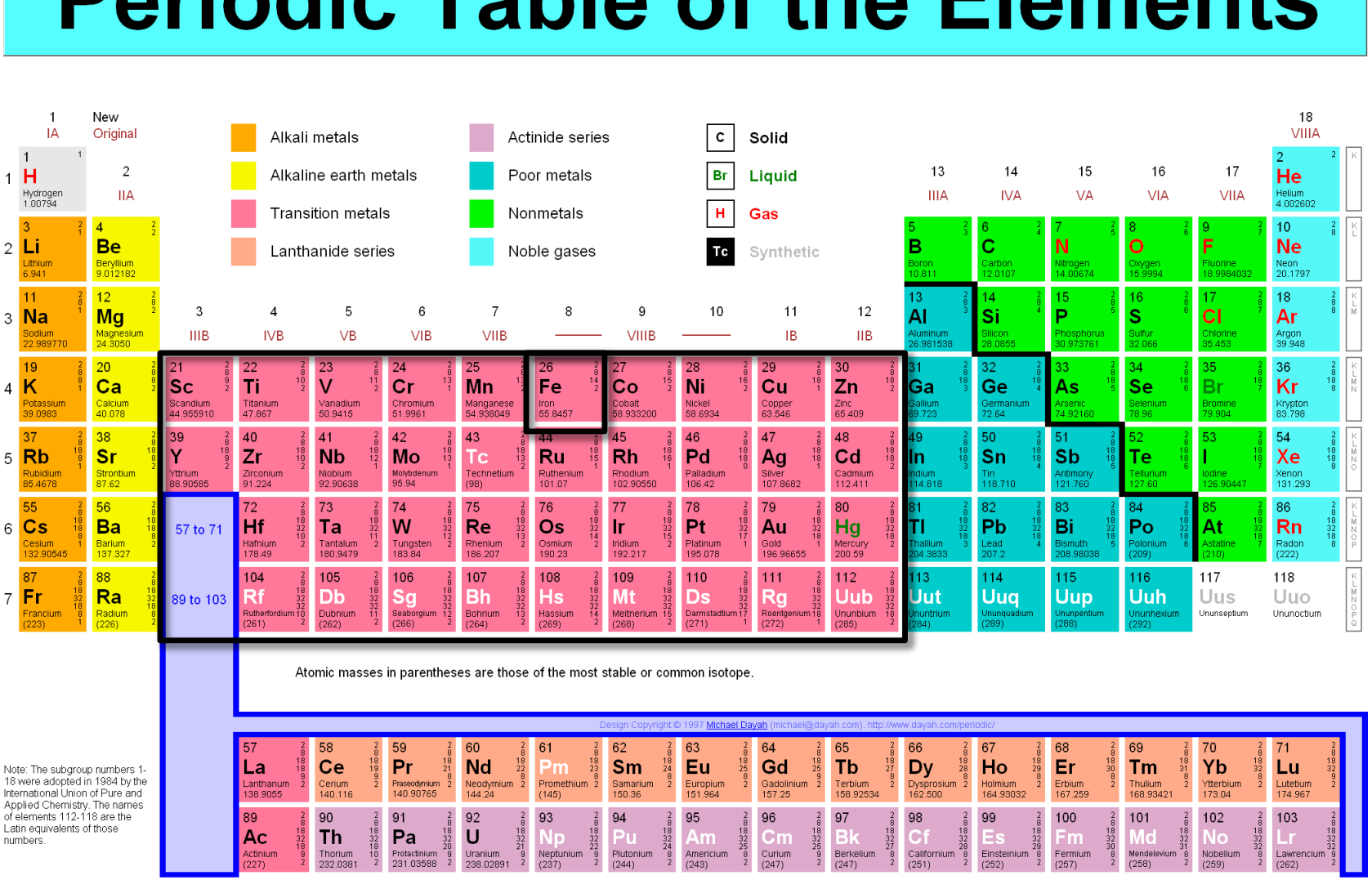
The electronic energy levels of an isolated ion are usually split and displaced when located in a solid. Unfilled d orbitals are split by interaction with surrounding ions and assume new energy values. These new energy values (transitions between them and consequently their spectra) are primarily determined by the valence state of the ion (Fe^{2+}, Fe^{3+}), coordination number, and site symmetry.

Energy Level Splitting in Solids: Part 1



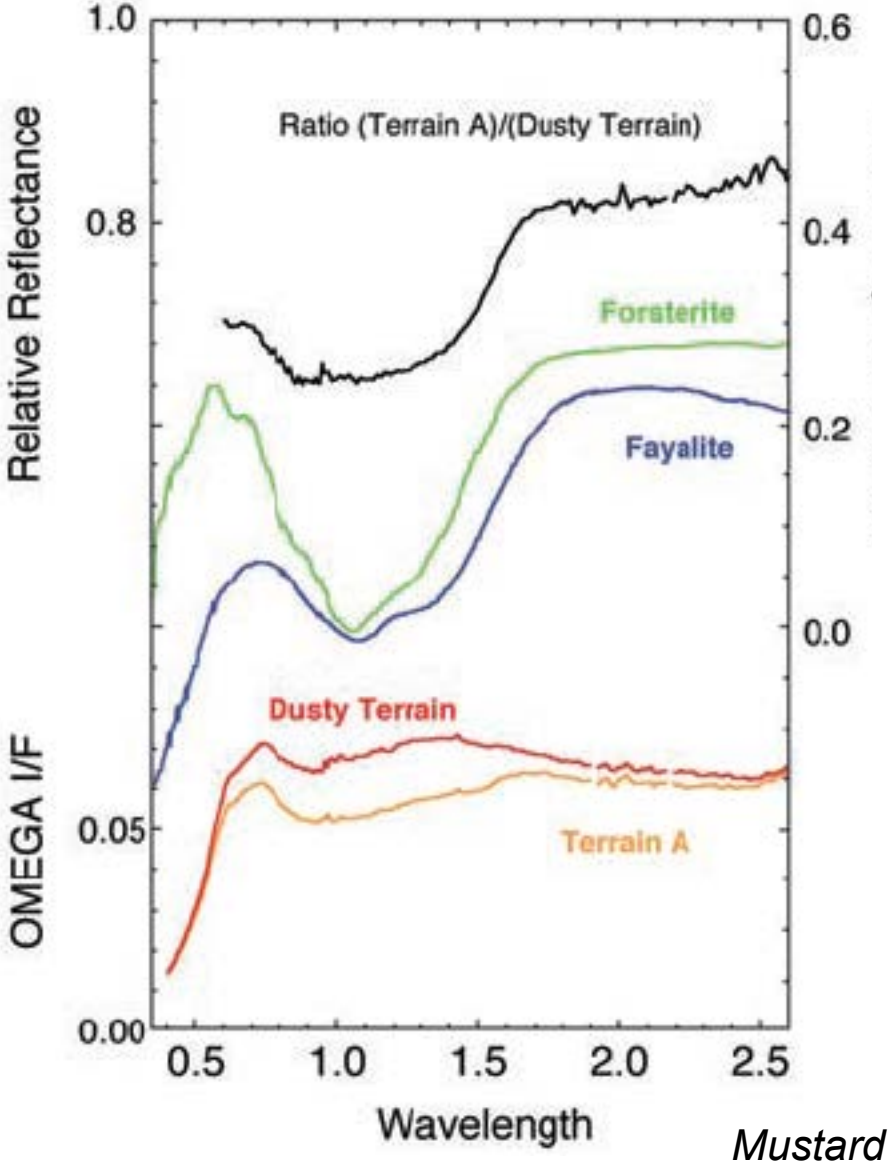
In a free atom these have equal energy, but not in a crystal…

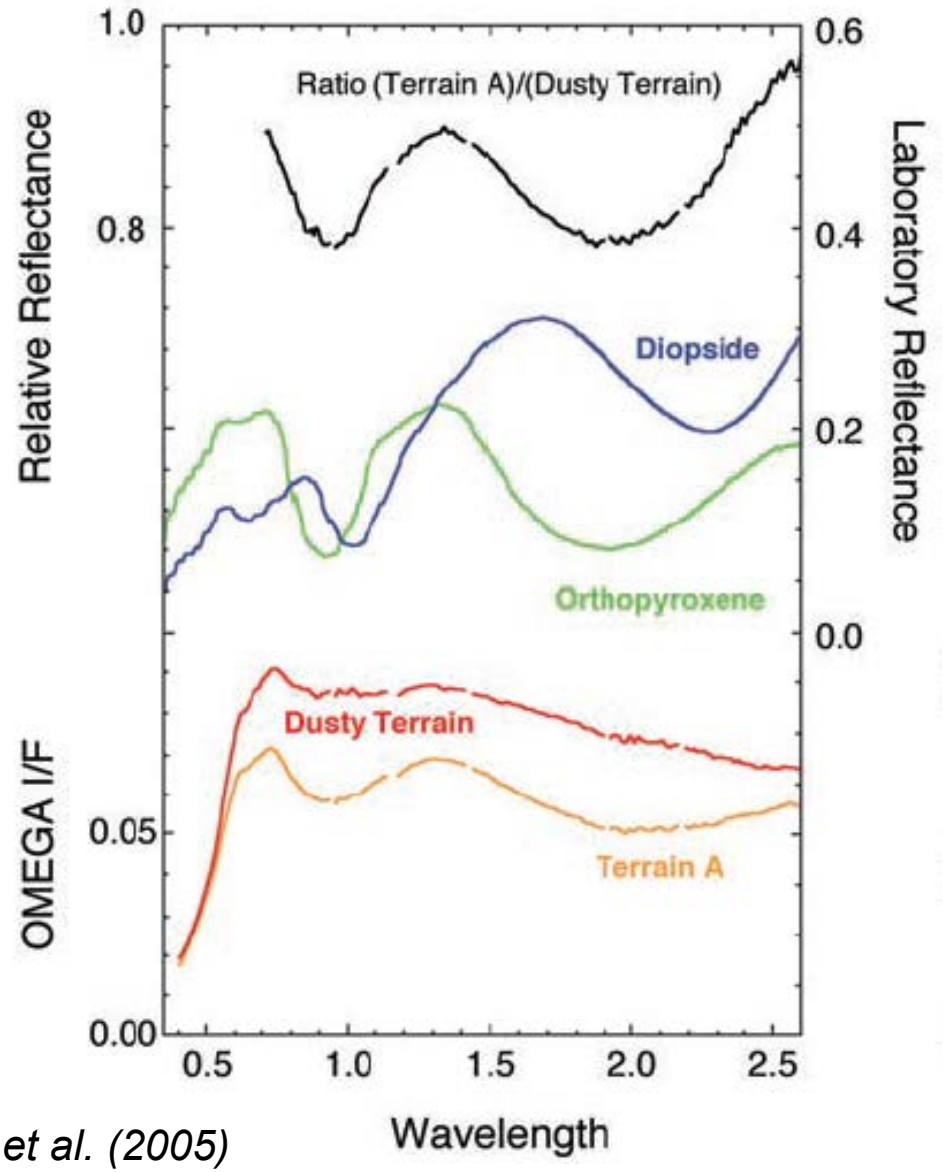
Unfilled *d* orbitals: the transition metals



Iron is the most geologically abundant transition metal

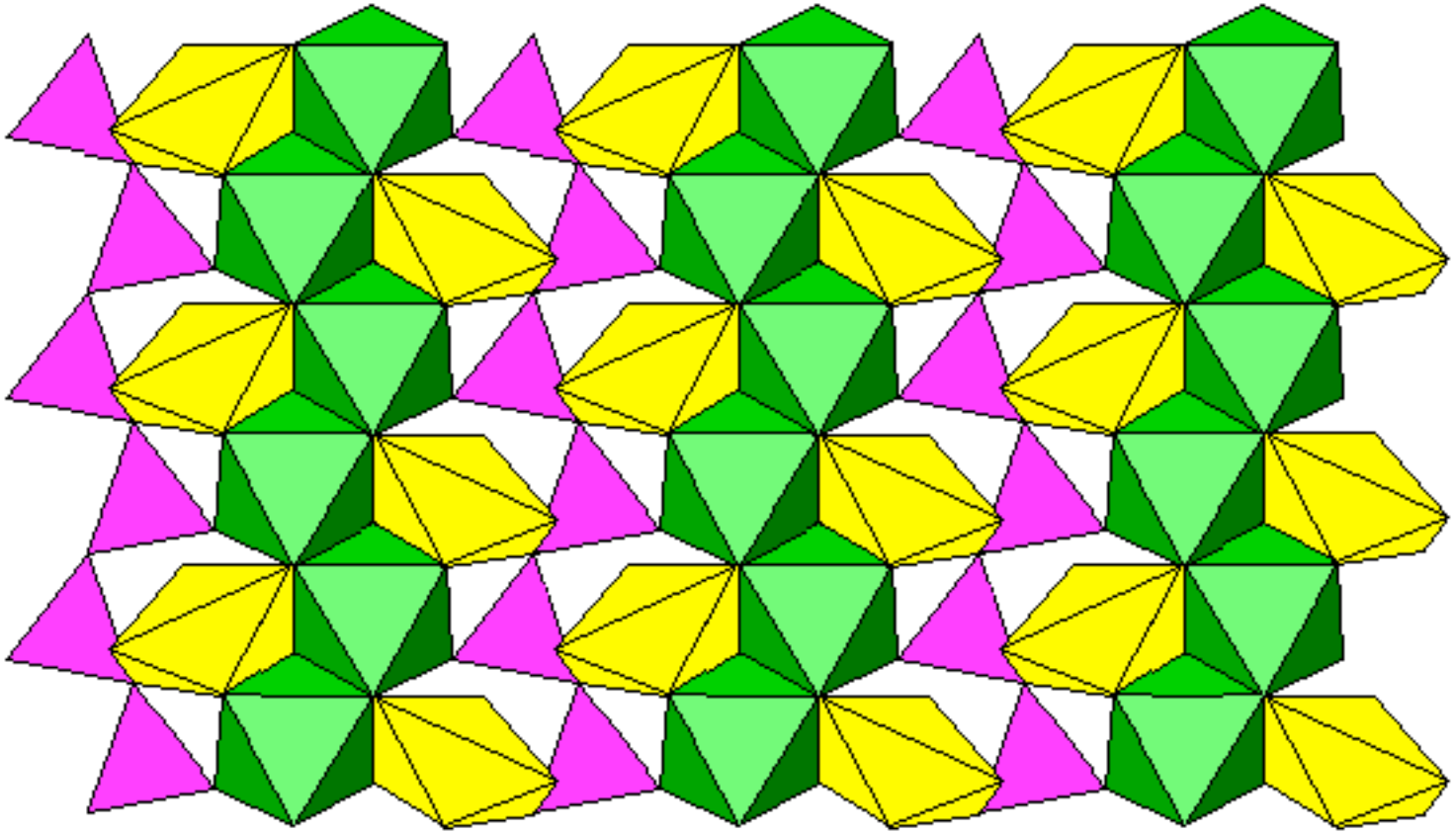
Fe electronic transitions in olivine, pyroxene





Mustard et al. (2005)

Energy Level Splitting in Solids: Part 2



Distortion of some “sites” in a crystal ➔ further energy splitting
➔ *diagnostic of mineralogy*

Spectroscopy: linking meteorites to asteroids