

**Topic D**

**“Part 3. Types of Spectra”**  
**(Kirchoff’s Laws)**  
(Web Version: 03-06-01)

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### Three Basic Types of Spectra

See *Study Guide*, Figure 6 ↔

- Described by Gustav Kirchoff (1859)  
(German physicist, 1824 – 1887)
- Types often given as “three laws”
- A “fourth type” also known

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### Types of Spectra\*

- 1) Continuous Spectrum
- 2) Emission (or Bright) Line
- 3) Absorption (or Dark) Line
- 4) Emission Line on Continuous

} “Kirchoff’s Laws”

Don't copy — it's here!

\*See Bottom of *Study Guide*, Figure 6

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### Types of Spectra\*


- Depend on  
— *physical state of source*
- What are the (three) *physical states*?

\*See Bottom of *Study Guide*, Figure 6

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### The Three Physical States

**Solid**

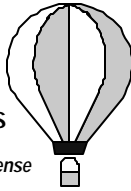


*Most Dense*

**Liquid**



**Gas**



*Least Dense*

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See Fig. 6. *Compressed (dense or high press.)* = about 1 standard (normal) atmos.

### Continuous Spectra


Hot Solid, Liquid or Compressed Gas

#1

↓

To Observer

Result #1






Continuous Spectrum

**EXAMPLES**

- Solids
  - Incandescent light bulb filament
  - Heating elements (stove, toaster, hair dryer, etc.)
- Liquids — molten iron
- Dense gas — ordinary air

Hints

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See Fig. 6. *Rarified* (low density or low press.) = much less than 1 standard atmos.

## Emission Line Spectra

Rarified Gas

Examples

- Air at low pressure
- Typical advertising ("neon") signs
- Street lamps
- Mercury vapor
- Sodium vapor (low press.)

To Observer

Result #2

Emission (Bright) Line Spectrum

Food to Go

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## A Box of Air

Normal Atmospheric Pressure

Continuous Spectrum

Watch how changing "high" pressure gas to "low" pressure gas transforms spectrum from *continuous* to *emission line*

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## Reduce Pressure

Remove Some Air

"Band" Spectrum

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## Air at Low Pressure

Remove More Air

Emission Line Spectrum!

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## Fingerprints of the Elements

Each substance has a unique emission line pattern

- Patterns are "signature" or "fingerprint" of element
- Permits chemical identifications

Hydrogen

Helium

Sodium

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## Spectral Bands

Sometime lines very wide

Spectral bands = wide spectral lines

Band

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### Comparison Spectra

Astronomers usually add to each stellar spectrum a reference spectrum (placed above & below)

Why? — Need lines to act as wavelength markers

Type used? — Emission line

Examples? — iron • neon • helium • argon

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[ This is a composite made by two or more sources ]

### Absorption Line Spectra

Hot Solid, Liquid or Compressed Gas #1 → Rarified (Cooler) Gas #2 → To Observer → Absorption (Dark) Line Spectrum

Examples: • The Sun • Most Stars

Know! Emission (Bright) Line Spectrum

Note: Same lines appear in absorption spectrum as appeared in the emission line spectrum from #2!

So gas (#2) absorbs light at same wavelengths it emits

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### Fingerprints Again

Like emission spectra . . .

*Dark lines permit chemical identification*

Usually many gases mixed together!

So identification often tedious and difficult

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### The Solar Spectrum

390 nm (Violet) to 460 nm (Blue)

460 nm (Blue) to 530 nm (Green)

530 nm (Green) to 610 nm (Orange)

610 nm (Orange) to 690 nm (Red)

690 nm (Red)

Ca II, Fe I, Hδ, Ca I, Hγ, Hβ, Mg I, Na I, Hα

About 67 elements have been identified in the solar spectrum

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[ This is also a composite made by two or more sources ]

### Emission on Continuous

Hot Solid, Liquid or Compressed Gas #1 → Rarified (Hotter) Gas #2 → To Observer → Emission (Bright) Line on Continuous Spectrum

This fourth type not originally described by Kirchoff

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### Basic Structure of Stars

- Most stars show absorption line spectra (including Sun)
- What does this tell you about star's structure?

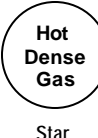
Star → Earth → See this


"Think about it"


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### What Can You Conclude?

<u>What Observed</u>	<u>What Implied</u>
Continuous spectrum ⇒	Star = Hot, dense gas
Dark lines ⇒	In front, cooler, rarefied gas





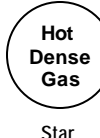




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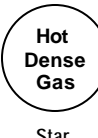
**But is this correct?**

- Probably not
- Why?
- Answer . . .

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### Answer

<u>What Observed</u>	<u>What Implied</u>
Continuous spectrum ⇒	Star = Hot, dense gas
Dark lines ⇒	In front, cooler, rarefied gas



**More likely:**

• ?

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