An introduction to the wonderful world of color

Dr. Lawrence D. Woolf

General Atomics

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SCIENCES EDUCATION FOUNDATION
GENERAL ATOMICS

Introduction-Color Confusion

- Primary colors are R, Y, B
- Primary colors are R, G, B
- Primary colors are C, M, Y
- Colors in rainbow: ROY G. BIV
- Increasing temperature: ROYWB
- Color of materials with increasing bandgap
  - K, R, Y, W

Ways to Explore Subtractive Color Mixing (Pigments: Ink or Paint)

- **Colored transparencies**
- Paint
- Colored water
- RGB LED light mixer
- Simulation using CMY model on MAC
- Simulation using CMY model- web applet
- Zip lock bags

Definition of Primary Colors

- No combination of 2 primary colors can produce a third primary color
- Combining the 3 primary colors can produce a wider range of colors than using any other 3 colors

Subtractive Colors Experiment
R, Y, B Primaries

- Overlap R and Y transparencies on W paper
  - Resultant color?
- Overlap R and B transparencies on W paper
  - Resultant color?
- Overlap Y and B transparencies on W paper
  - Resultant color?

Subtractive Colors Experiment
R, Y, B Primaries

- Overlap R and Y transparencies on W paper
  - Red
- Overlap R and B transparencies on W paper
  - Black
- Overlap Y and B transparencies on W paper
  - Black

R, Y, B are not appropriate primaries

Traditional artist's color wheel is incorrect

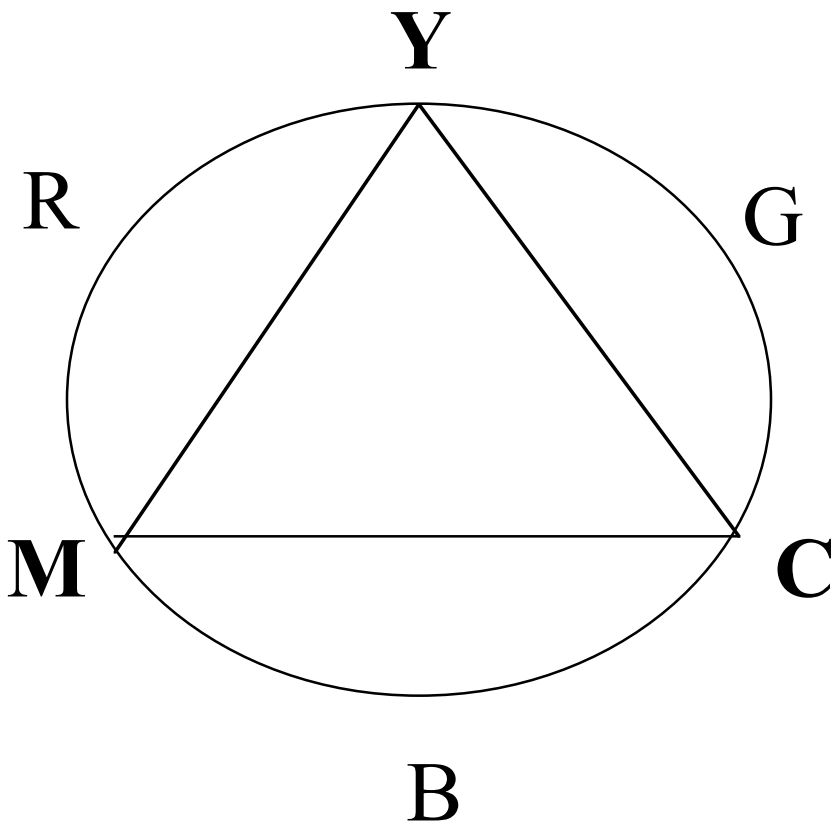
Subtractive Colors Experiment
C, M, Y Primaries

- Overlap C and M transparencies on W paper
  - Resultant color?
- Overlap M and Y transparencies on W paper
  - Resultant color?
- Overlap Y and C transparencies on W paper
  - Resultant color?

Subtractive Colors Experiment
C, M, Y Primaries

- Overlap C and M transparencies on W paper
  - Blue
- Overlap M and Y transparencies on W paper
  - Red
- Overlap Y and C transparencies on W paper
  - Green
- Red and blue can be made by mixing other colors - not subtractive primary colors
- CMY are correct subtractive primary colors

Color Wheel Model for Subtractive Colors (Pigments)



Complementary Colors Experiment

- Overlapping complementary colors of pigment produce black
- Overlap C, R films
- Overlap M, G films
- Overlap Y, B films
- Complementary colors lie on opposite sides of the color wheel
- Demonstration using 2 color wheels

Ways to Explore Additive Color Mixing (Light)

- 3 slide projectors: R, G, B (typical)
- 2 slide projectors - better!
  - RG, GB, BR, then RC, GM, BY
- Observe colors on monitor with 8x magnifier
- RGB LED light mixer
- Simulation using RGB model on MAC
- Simulation using RGB model web applet
- **Use color wheel and transparencies**

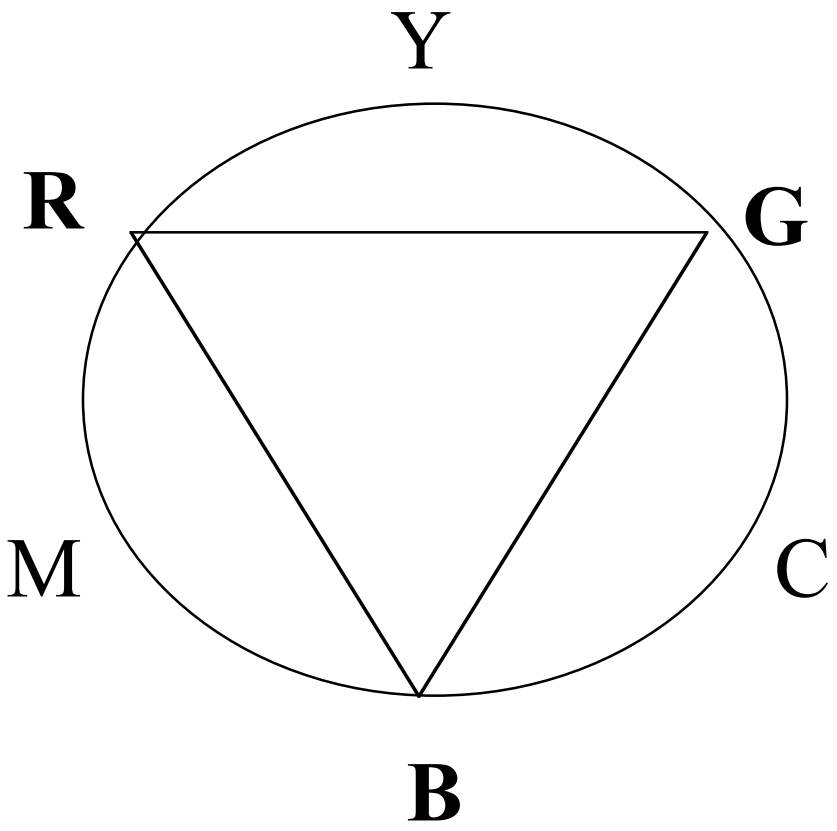
White Light Experiment

- Place C film over color wheel on W paper
  - C film absorbs R light
- Place M film over color wheel on W paper
  - M film absorbs G light
- Place Y film over color wheel on W paper
  - Y film absorbs B light
- Place C, M, Y films on top of each other
  - White light is completely absorbed by the R light absorber,G light absorber, and B light absorber
  - **So white light: W=R+G+B**

Additive Color Mixing

- W = R + G + B
  - W paper is a source of reflected W light
- R + G = W - B = Y
  - Place Y film (blue absorber) on W paper (white light source) to generate W-B light
- G + B = W - R = C (C absorbs R light)
- B + R = W - G = M (M absorbs G light)

Color Wheel Model for Additive Colors (Light)



Color wheel for light and pigments is the same!

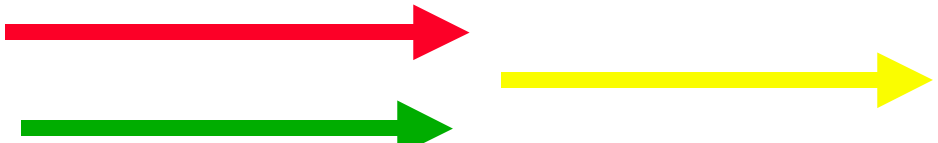
Complementary Colors

- Overlapping complementary colors of light produce white
- C, R
- M, G
- Y, B
- Complementary colors lie on opposite sides of the color wheel
- Same as for subtractive colors

Color Models

Math: R + G = Y

Pictorial:



Graphical:

Also color cube for RGB

Other Color Materials

- CMY Gradient Strips
- Handheld microscope (Radio Shack)
- Color transparencies, color wheels
- CMY color wheel components
- Color wheels and color rings
- It’s a Colorful Life

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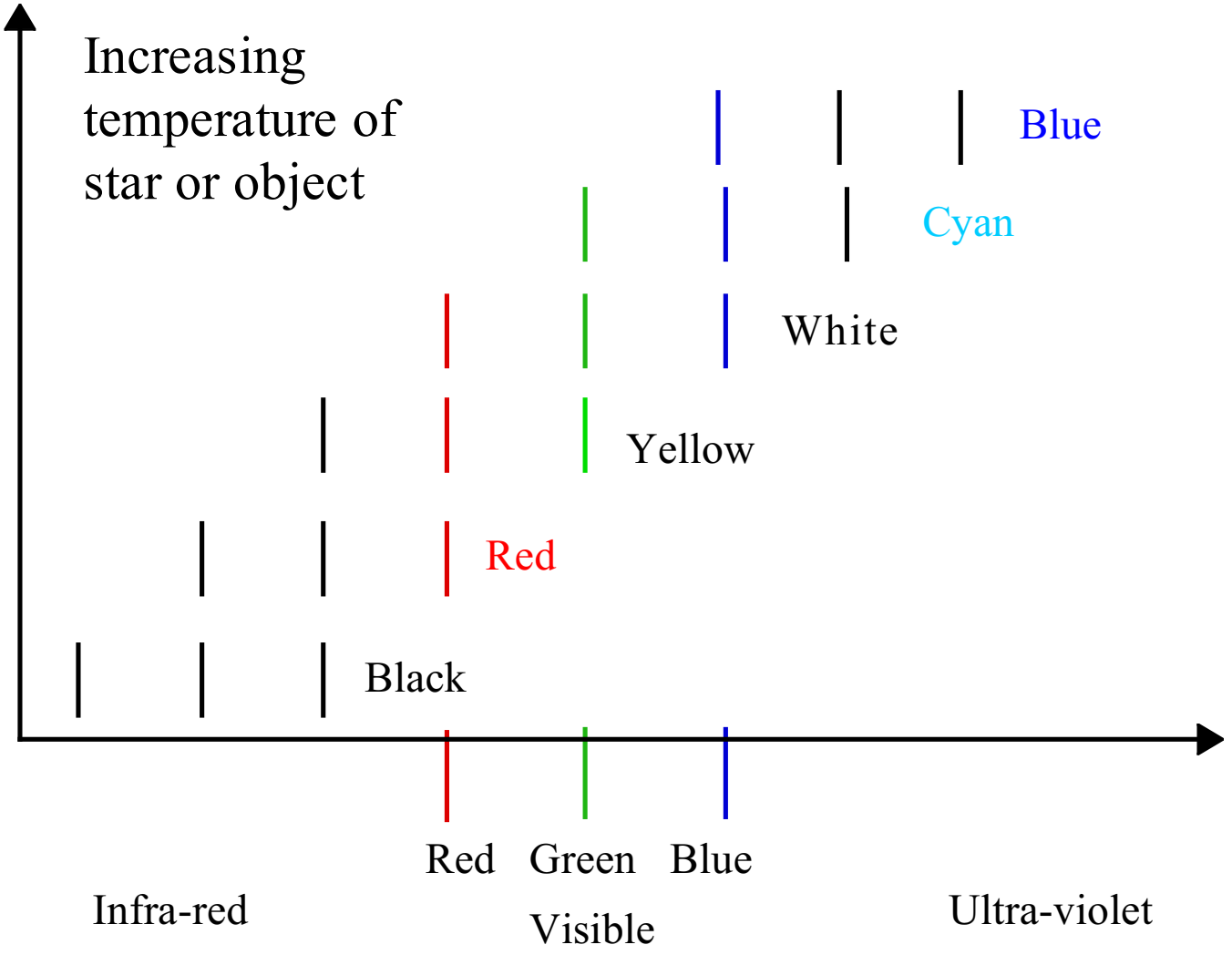
Application of additive color mixing



Band gap colors-
application of subtractive color mixing

Band gap in IR	Absorbs E > IR (absorbs R, G, B)	W-R-G-B = K Material is black
Band gap in R	Absorbs E > R (absorbs G, B)	W- G - B = R Material is red
Band gap in G	Absorbs E > G (absorbs B)	W-B=R+G=Y Material is yellow
Band gap in B	Absorbs E > B (no absorption)	Material is white (colorless)

Conclusion-Color Clarification

- Primary colors of light are R, G, B
- Primary colors of pigment are C, M, Y
- Primary colors of painting are not R, Y, B
- Color of stars can be understood using additive color mixing
- Band gap colors can be understood using subtractive color mixing