Dynamical Range in Astronomical Images

MAKING THE UNIVERSE BEAUTIFUL!

Dr. Robert L. Hurt
Spitzer Science Center

Lars Lindberg Christensen
ESA/Hubble
What is Dynamic Range?
Now for the rest of the Universe...
Dynamic Range (DR) Details

- **Ratio** of *brightest* to *faintest* features of interest
- Computers distinguish 256 discrete levels (per color)
- Displays typically attain ~ 300:1 to 1,000:1
- The human eye can achieve ~10,000:1
- The universe exceeds *trillions*:1 (here and there, anyway)
- Must **compress** DR to show everything!
Step-By-Step

- Reset black & white levels

SOMBRERO GALAXY

GALAXIES OFTEN HAVE HIGH DR
Step-By-Step

- Reset black & white levels
- Clipping: lost info!
Step-By-Step

- Reset black & white levels
- Clipping: lost info!
- Apply a mathematical function to compress DR
- See full range of data
Step-By-Step

- Reset black & white levels
- Clipping: lost info!
- Apply a mathematical function to compress DR
- See full range of data
- Your choice: trade contrast for depth
From Data to Picture

RAW "FITS" DATA
0010010110100100
1110001000010001

"SCALE" THE DATA
(SET BKG & PEAK)

APPLY A NON-LINEAR
"STRETCH" FUNCTION

"RENDER" THE DATA
TO AN IMAGE (0-255)
Stretch Function Images

- Linear()
- Sqrt()
- Log()
- ASinH()
- Log(Log())
- CubeRoot()
- Log(Sqrt())
Stretch Function Graphs

Normalized Input vs. Stretched Normalized Output

- Linear
- Sqrt
- CubeRoot
- Log
- ASinH
- Log(Sqrt)
- Log(Log)

Peak Value = 50
Stretch Function Graphs

Normalized Input

Stretched Normalized Output

Linear
Sqrt
CubeRoot
Log
ASinH
Log(Sqrt)
Log(Log)

Peak Value = 50
Stretch Function Graphs

[Graph showing various stretch functions with linear, square root, cube root, log, asinh, log(sqrt), and log(log) curves. The peak value is marked at 50.]
Stretch Function Graphs

Normalized Input
Stretched Normalized Output

Linear
Sqrt
CubeRoot
Log
ASinH
Log(Sqrt)
Log(Log)

Peak Value = 50

Normalized Input (Log scale)
Stretch Function Graphs
Stretch Function Graphs

The graph illustrates various stretch functions applied to a normalized input. The normalized input values range from 0.001 to 1.000 on a logarithmic scale, while the stretched normalized output values range from 0.0 to 1.0.

The functions include:
- Linear
- Sqrt
- CubeRoot
- Log
- ASinH
- Log(Sqrt)
- Log(Log)

The peak value for these functions is set at 50, indicating the maximum output value.

The graph shows how each function transforms the input values, with Linear being a straight line, and others showing more pronounced curvature as the input increases.
Mismatched Dynamic Ranges

SPITZER IRAC CHANNELS 1 (GREEN) & 2 (RED)
Mismatched Dynamic Ranges

SPITZER IRAC CHANNELS 1 (GREEN) & 2 (RED)

CUBE ROOT (GREEN)
ASINH (RED)
Mismatched Dynamic Ranges

SPITZER IRAC CHANNELS 1 (GREEN) & 2 (RED)

CUBE ROOT (GREEN)  
ASINH (RED)

CUBE ROOT (GREEN)  
CUBE ROOT (RED)
FITS Liberator: A Tool For DR Compression

- ESA/ESO, NASA Collaboration
- Direct import of FITS data into Photoshop
- Powerful tools for managing dynamic range
  - Multiple stretch functions
  - Dynamically updating histogram
  - Flexible background/peak scaling
  - Independant black/white levels
Local Adjustments:
Selective Compression by Image Compositing
Proximity Adjustments

Photoshop Filter: Highlights/Shadows
Ethical Imaging
Ethical Imaging

- Is it “fair” to manipulate dynamic range?
- Display technology is LIMITED
  - Images can NOT be displayed “correctly!”
- Image *perception* is the important issue
- Visual comprehension of image
- Engagement

*Always document what has been done!*
Summary
Summary

- There is more than one way to render an image
- 1 set of FITS files... a gallery full of possibilities!
- Many tools exist to manage dynamic range
  - FITS Liberator
  - Photoshop
- Other display packages too!
- Display your full range!
- Apply the appropriate function before you import
- Fine-tune for best impact afterwards
For more information:

http://www.spacetelescope.org/projects/fits_liberator/

Or Google the term “FITS Liberator”