Mega-Constellations of Satellites and Optical Astronomy

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New Mega-Constellations

- **Bright! The new satellites could be brighter than 99% of all objects in orbit now.**
- Now – maybe 200 objects can be seen with eye (not all at once).
- End of 2020 – SpaceX will add another 1584! 9x increase.

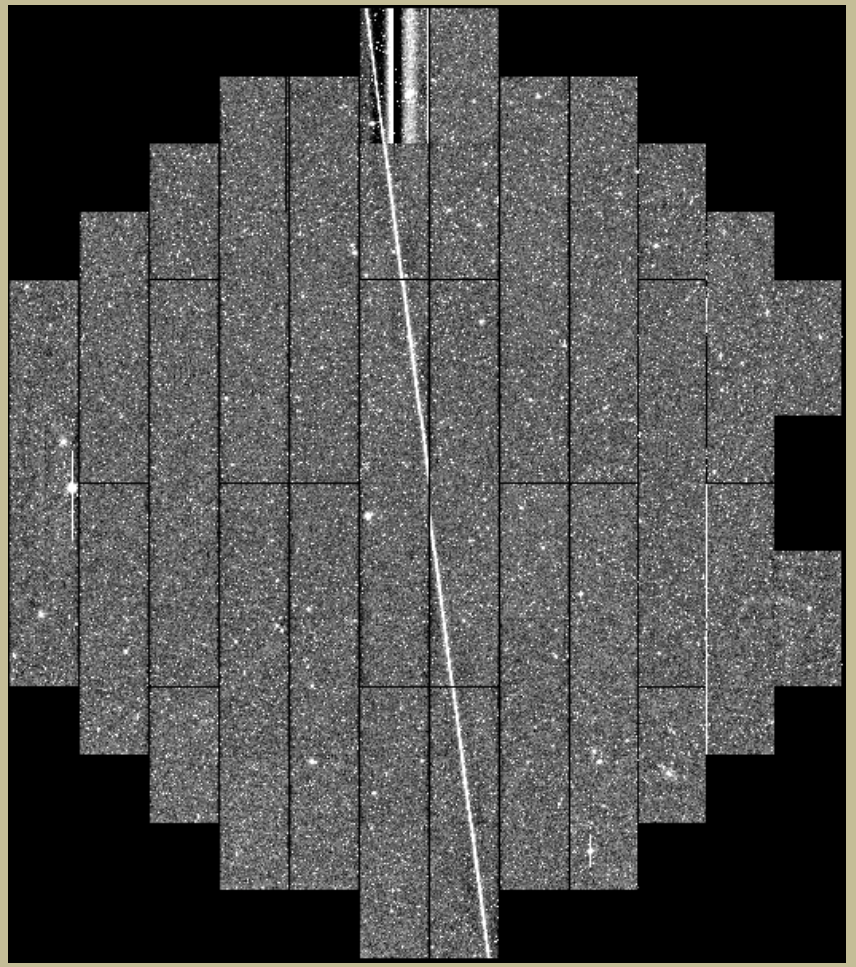
LSA ASTRONOMY
UNIVERSITY OF MICHIGAN

2019-July-16 UT

Blanco 4.0-m DECAM

Cerro Tololo, Chile

2.2 deg FOV



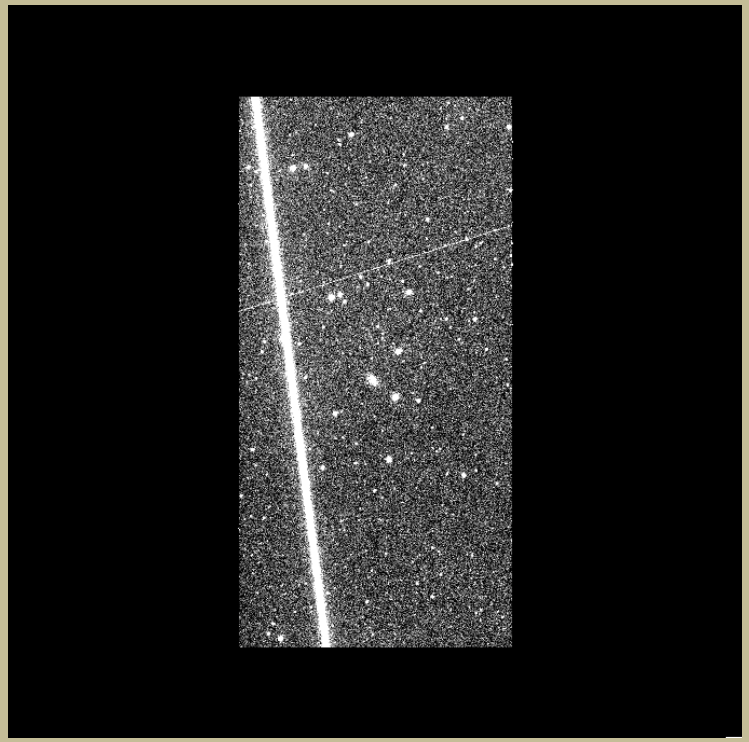
60 sec exposure
r' filter

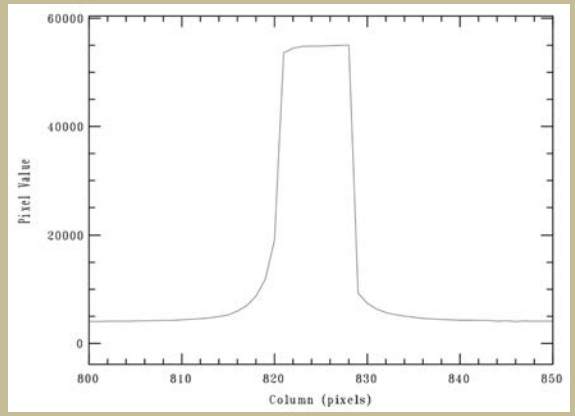
Atlas Centaur 2 R/B

1963-047A 00694

V ~ 4^{th} – 10^{th}

Streak saturates Detector





- Loss of information in pixels.
- Cross-talk in electronics.
- Ghost images.
- Possible residual images.

Conclusions

- Mega-constellations at LEO are coming and coming fast!
- New satellites brighter than 99% of current objects in orbit.
- Only small fraction of total constellation visible at any one time.
- ‘string of pearls’ probably not a good representation of final operational state.
- If 1584 Starlinks were the only constellation to be launched, astronomers could handle it. BUT – just the start!

Legacy Survey of Space and Time
Opening a Window of Discovery on the Dynamic Universe

LSST and SpaceX

- The LSST survey is most impacted by bright satellite trails because of its unprecedented wide-deep-fast coverage of the sky 2022-2032.
- Original Starlinks will saturate LSST detectors.
- Joint LSST-SpaceX engineering teams working to change this:
  - Make satellites fainter to avoid LSST detector saturation.
  - Changes to LSST readout to reduce artifacts from trails.
  - Changes to scheduling to avoid most bright satellites.
- We find that SpaceX is committed to solving this problem.

Tony Tyson, LSST Chief Scientist tyson.physics@gmail.com

Final thoughts on Starlinks

- At operational orbit of 550 km and attitude, 1st generation of Starlinks V ~ 5th magnitude. Visible to eye under very good conditions.
- Any sort of effort to reduce brightness should make next generation Starlinks fainter than eye limit. Still challenge for telescopes.
- 'Strings of pearls' at parking/checkout/deployment orbits of 350 km will be increasingly common:
  - Two such strings now visible.
  - More to come.
  - Just visible till astronomical twilight.

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