

SUSTAINED GAMMA-RAY SOLAR FLARE EMISSION: EVIDENCE FOR SHOCK SOURCE

Solar flares are huge explosions on the Sun that release light over the entire electromagnetic spectrum – from radio waves to visible light to the most energetic light: gamma-rays. They last from minutes to several hours, and in a few cases gamma-rays have been observed long after the flare, up to almost a day.

What is the science question?

What is the cause of "long-duration" gamma-ray solar flares or Sustained Gamma-Ray Emission (SGRE)?

What are the findings?

Goddard research combined simultaneous observations from three NASA missions -- Fermi, SOHO, and Wind to show that these "long-duration" gamma-rays are created as the end result of a process initiated by coronal mass ejections, or CMEs – giant eruptions of solar material – on the Sun. The CMEs set up shock waves, which in turn drive protons into the Sun and cause gamma-rays to be emitted.

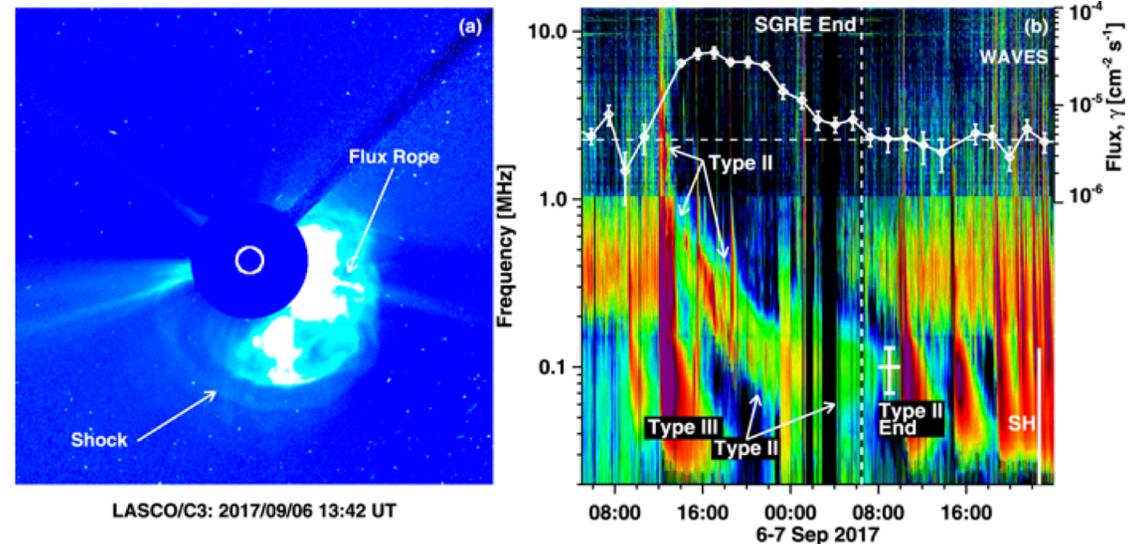
What is the impact?

This answers the decades old mystery about "long-duration" gamma-ray solar flares. This includes the question of whether they originate from trapped particles or some extended particle acceleration, i.e. CME shock acceleration.

Why does it matter?

This work tells us about the fundamental dynamics and timing of solar flares and associated particle acceleration in solar eruptions. These not only tell us more about the fundamental physics, (which is applicable to objects throughout the universe), but helps with prediction of space weather phenomena.

Nat Gopalswamy, Pertti Mäkelä, Seiji Yashiro, Alejandro Lara, Hong Xie, Sachiko Akiyama, and Robert J. MacDowall, "Interplanetary Type II Radio Bursts from Wind/WAVES and Sustained Gamma-Ray Emission from Fermi/LAT: Evidence for Shock Source", *The Astrophysical Journal Letters*, Volume 868, Number 2. <https://doi.org/10.3847/2041-8213/aaef36>.



(a) SOHO/LASCO CME with shock and magnetic flux rope. (b) Wind/WAVES radio burst data with the FERMI SGRE (sustained gamma-ray event) data overlaid in white. The shock arrival time at Earth is marked "SH." SGRE ends when the radio burst ends (both due to the shock)



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