Flux emergence rate in the quiet Sun from SUNRISE data

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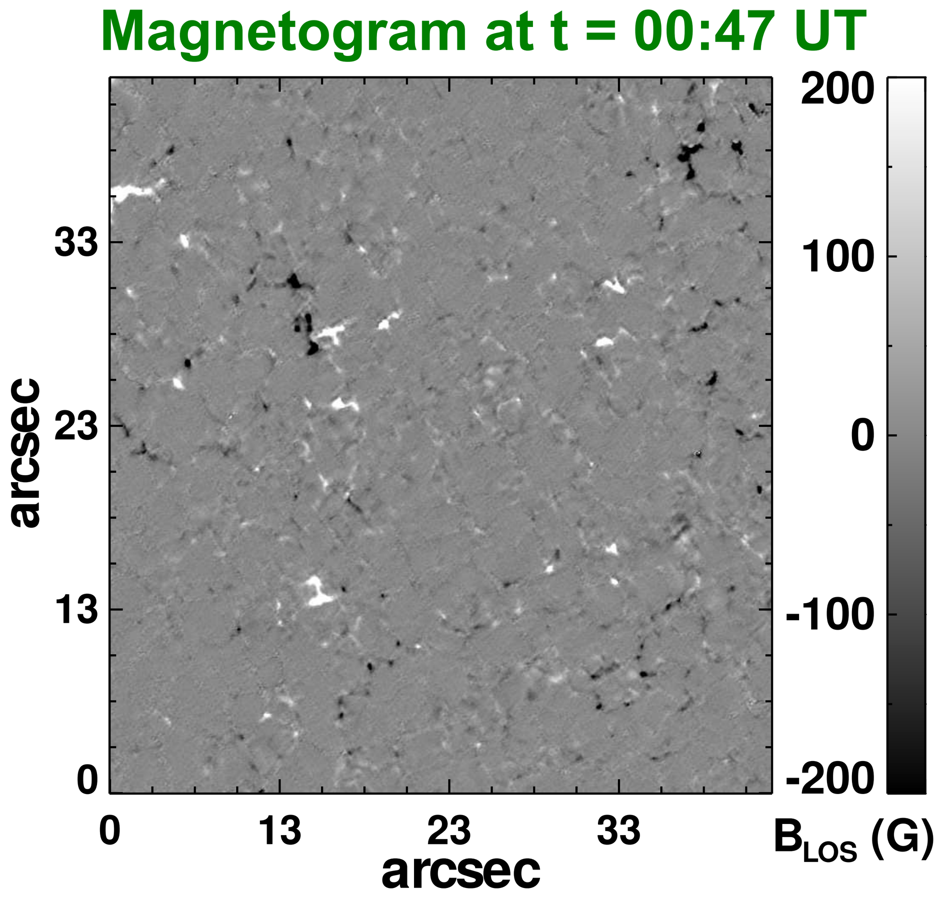
Abstract

The small-scale internetwork features are thought to be the major source of fresh magnetic flux in the quiet Sun. The balloon-borne observatory SUNRISE-I (2009), observed the quiet Sun at a high spatial resolution, making it possible to measure flux as low as 9×10^{14} Mx (Anusha et al. 2017). Using this data, Smitha et al. (2017) measured a **flux emergence rate (FER) of $1100\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$** by including fluxes in the range $10^{15} - 10^{18}$ Mx. **This is an order of magnitude higher than the FER from *Hinode* obtained from a similar method.**

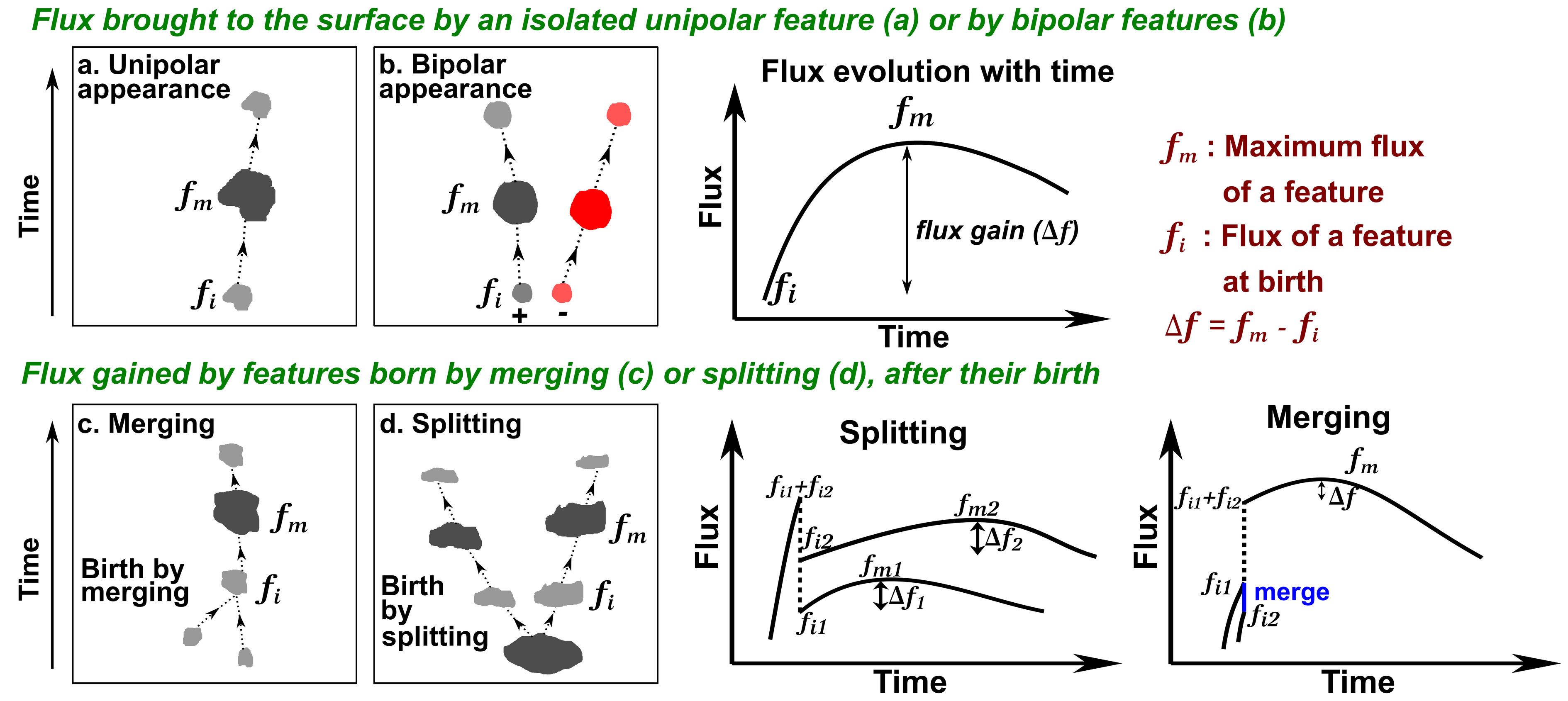
Data

Magnetogram at t = 00:47 UT



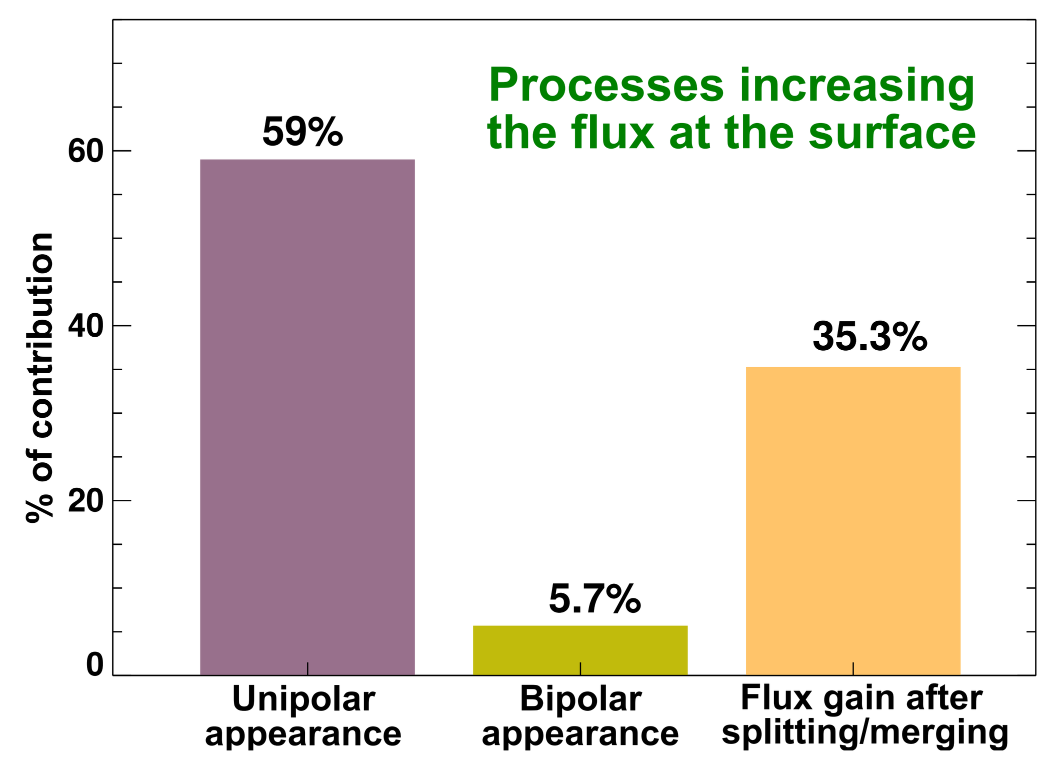
- **Instrument**: Imaging Magnetograph eXperiment (IMaX) onboard SUNRISE
- **No. of images**: 42; **Cadence**: 33s; **FOV**: $43'' \times 43''$; **spatial resolution**: $0.''15 - 0.''18$; **Noise**: $1.5 \times 10^{-3} I_c$
- Feature identification, tracking and flux measurement done in Anusha et al. (2017)
- **Smallest flux**: 9×10^{14} Mx which is nearly an order of magnitude smaller than from *Hinode*; **largest flux**: 2.5×10^{18} Mx
- B_{LOS} determined using center of gravity method

Processes increasing flux at the solar surface

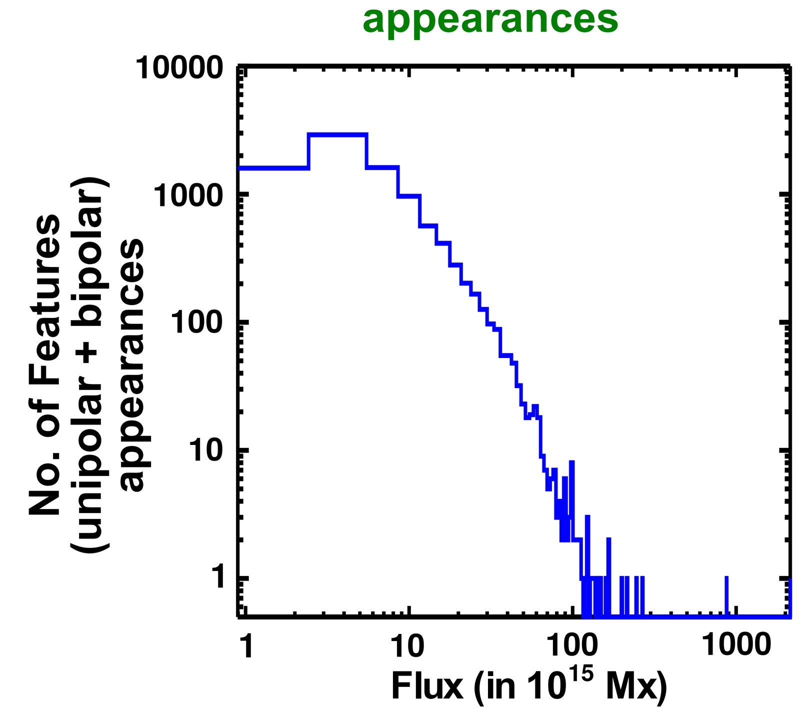


Results

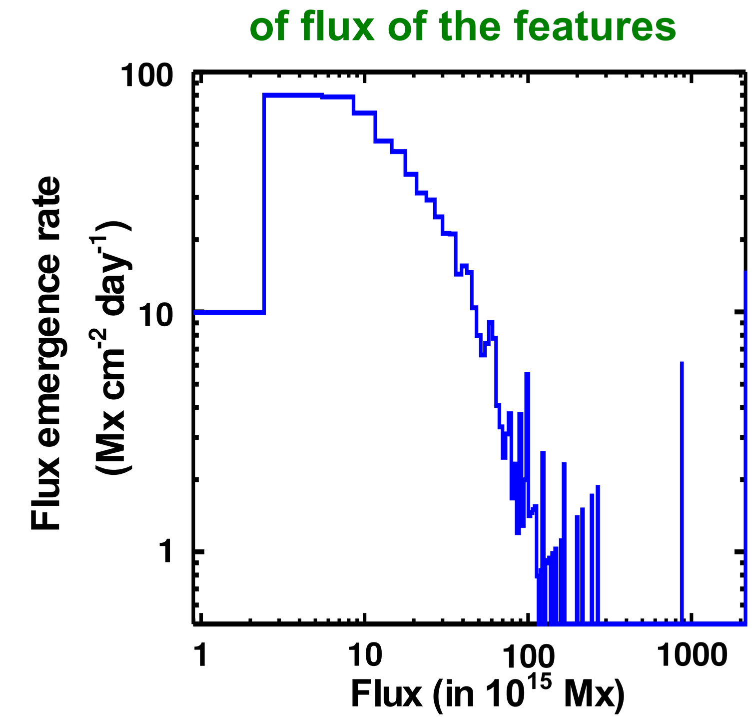
- FER measured is $1100\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$
- If the whole Sun is assumed to be as quiet as SUNRISE FOV then global FER is $6.6 \times 10^{25}\,\mathrm{Mx\,day^{-1}}$
- Unipolar appearances contribute 59% and the bipolar appearances contribute 5.7% to the FER.
- The rest 35% is the flux gained by split or merged features after their birth
- Over 65% of the detected features carry flux $\leq 10^{16}$ Mx (dominant contributors to the FER)
- The estimated flux loss rate from the same dataset is $1150\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$



Histogram of no. of features born by unipolar and bipolar appearances



Flux emergence rate as a function of flux of the features



Comparison with previous studies

Paper	Instrument	Lowest measured flux	Method	Flux emergence rate	Details
Gošić et al. (2016)	*Hinode*	6.5×10^{15} Mx	Tracking the evolution of individual features as done in Anusha et al. (2017)	$120\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$ or $3.7 \times 10^{24}\,\mathrm{Mx\,day^{-1}}$	The lowest measured flux is nearly an order of magnitude smaller than from SUNRISE. Hence FER is an order of magnitude smaller
Thornton & Parnell (2011)	*Hinode*	10^{16} Mx	Emergence events detected using three different methods. FER is then determined by fitting a power law to the distribution of frequency of emergence	$35 - 450\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$ or $2.0 - 28.7 \times 10^{24}\,\mathrm{Mx\,day^{-1}}$	High values of FER are from the Bipole comparison method which counts the same feature multiple times
Zhou et al. (2013)	*Hinode*	6×10^{15} Mx	It is assumed that every three minutes, the internetwork features replenish the flux at the solar surface with an average flux density of 12.4 G	$1.2 \times 10^{4}\,\mathrm{Mx\,cm^{-2}\,day^{-1}}$ or $3.8 \times 10^{26}\,\mathrm{Mx\,day^{-1}}$	Higher FER due to an overestimation of the average flux density. From the SUNRISE data, we get 2.8 G without noise, 10.7 G with noise.

References

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