On the Solar Open Magnetic Flux Problem

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Abstract

The solar magnetic fields emerging from the photosphere into the chromosphere and corona are comprised of a combination of “closed” (field lines with both ends rooted at the Sun) and “open” (field lines with only one end at the Sun) fields. Since the early 2000’s, the magnitude of total unsigned open magnetic flux estimated by coronal models has been in significant disagreement with in situ spacecraft observations, especially during solar maximum. Estimates of total open unsigned magnetic flux using coronal hole observations (e.g., using extreme ultraviolet (EUV) or Helium (He) are in general agreement with the coronal model results and thus show similar disagreements with in situ observations. This paper provides a brief overview of the problem, summarizes the proposed explanations for the discrepancies, and presents results that strongly support the explanation that the discrepancy is due to dynamics at the open-closed boundary. These results are derived from determination of the total unsigned open magnetic flux, utilizing the Wang-Sheeley-Arge (WSA) model at a particular spatial resolution and different field-line tracing methods. One of these methods produces excellent agreement with in situ observations. Our results imply that active regions residing near the boundaries of mid-latitude coronal holes are the primary source of the missing open flux. Furthermore, they resolve many of the seemingly contradictory facts that have made resolving the open-flux problem so difficult.