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Chinese Astronomy and Astrophysics 39 (2015) 66–77
CHINESE ASTRONOMY AND ASTROPHYSICS

Multi-wavelength Analysis to Solar Corona Heating Events† ⋆

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Abstract With the advent and successful operation of the 1.6 m aperture New Solar Telescope of Big Bear Solar Observatory (BBSO/NST), solar observation has entered the era of high resolution better than 0.1″. This permits us to carry out the case studies of single coronal heating events, to provide the original high-resolution observational evidence for finally solving the problem of coronal heating. By combining the high-resolution Helium I 10830 Å, TiO 7057 Å, and H_α blue-wing (-0.7 Å) imaging data from the NST with the imaging data of extreme ultraviolet and longitudinal magnetic field observed simultaneously by the Atmospheric Imaging Assembly (AIA) and Helioseismic and Magnetic Imager (HMI) on board of the Solar Dynamics Observatory (SDO), we have analyzed the evolution of magnetic field in two tiny dynamical events of coronal heating (brightening of magnetic loops) that originate from the solar intergranular lanes. It is found that the footpoints of both brightening magnetic loops were all located in the one side of nearby neutral line of magnetic fields, the footpoints of one magnetic loop were accompanied by the disappearance of a small longitudinal magnetic element and the newly formed connection between two granulations, while the footpoints of another magnetic loop were accompanied by a weak variation of longitudinal magnetic field and the breakdown of a granulation. The observed result tends to suggest that the low-temperature and high-temperature outflows were produced simultaneously by the magnetic reconnection occurred among the solar granulations in the low-layer atmosphere. Meanwhile, it is noted that the high-resolution and high-accuracy polarization measurement of photospheric magnetic field is crucial for finally solving the problem of coronal heating.

† Supported by National Natural Science Foundation (11333009, 11173062)
Received 2013–06–18; revised version 2013–11–25
⋆ A translation of *Acta Astron. Sin.* Vol. 55, No. 3, pp. 193–202, 2014
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doi:10.1016/j.chinastron.2015.01.007

Key words sun: corona, sun: chromosphere, sun: magnetic fields

1. INTRODUCTION

In the forties of the 20th century the researchers acknowledged that the coronal emission line at 5303 Å (coronal green line) is emitted from the thirteen-times-ionized iron (Fe XIV, see Swings[1]), thus to confirm that the temperature in the solar corona is up to 10^6 K, about three orders of magnitude higher than that of the photospheric atmosphere. Because the second law of thermodynamics does not allow the quantity of heat flows from a low-temperature body to a high-temperature body, there should be some unknown heating mechanism to play a role continuously. Otherwise, the radiation loss produced by such a high-temperature atmosphere will make the solar corona cool down very soon. What kind of heating mechanism to keep the existence of high-temperature corona is called "the problem of coronal heating", which is always a puzzle for solar physicists up to now. Briefly speaking, in order to solve "the problem of coronal heating", it is necessary to find a reasonable physical mechanism to heat the solar corona up to several million degrees. In addition, any successful theory for coronal heating should have an observable quantity to serve for the final observational verification. Fig. 1 shows "the coronal heating process" proposed by Klimchuk[2] in a review paper, which is necessary for any coronal heating theories.

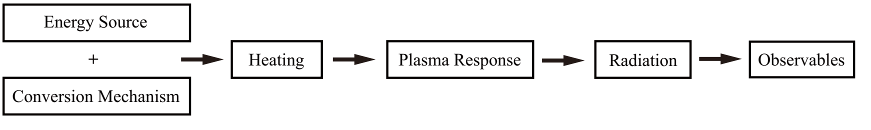

Fig. 1 Necessary components of a coronal heating model[2]

From this flow diagram we can see that any successful models for coronal heating have to reconstruct the coronal radiation so as to be tested as an observable quantity. It is equally important that we have to make clear of the source region of energy and the physical mechanism of energy conversion, hence we have to use high-resolution instruments to observe the different layers of solar atmosphere simultaneously. All active phenomena in the sun are always closely linked to the solar magnetic field. The imaging observations of space satellites at extreme ultraviolet (EUV) and soft X-ray wavebands have shown that the solar corona is composed of a great amount of tiny, discrete, and closed magnetic loops. Hence, the elementary structure of solar corona is a magnetic loop, which is originated from the photospheric magnetic field, and is filled with a great amount of highly-magnetized plasmas of different temperatures and densities. According to the dynamo theory, solar magnetic field is produced in the convection zone. Because of their instability, magnetic field lines emerge continuously from the photospheric surface, and thus forms the solar surface magnetic field. Solar magnetic field plays a key role in almost all the theories of coronal heating.