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H-ALPHA EMMISSION IN SOLAR CORONA

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Abstract. Some of earlier observations where H-alpha emission in solar corona mainly up to 0.6 solar radii above the Moon's limb was detected in eclipse and in daily coronagraphic observations are reviewed. A proper theoretical explanation of this cold chromospheric-type emission in the hot corona does not exist yet. A possible Belgrade Astronomical Observatory program for detection of H-alpha emission as large or small scale coronal structures is outlined.

1. INTRODUCTION

When one learns about the solar atmosphere it is usually presented in layers as photosphere, chromosphere and corona. But in reality the division is not that rigid. First, "reversing layer" between photosphere and chromosphere was invented.Then the chromospheric prominences were "admitted" to extend high in corona. Something here was called the transition region - but not the transition layer. Corona has been found lurking behind spicules. Finally, in spite of generally accepted high temperatures in corona (more than 10^6 K), some low excitation spectral lines corresponding to typical chromospheric temperatures (definitelly much less than 10^5K) were found in the inner as well as in the outer corona.

This process of comprehention wasn't an easy one. It has lasted for more than a century.Now most of solar physicists are convinced in the coronal origin of those low excitation emission regions. However, their sizes, locations in the corona, appearances, time-variations and possible theoretical explanation are not well established yet.

So, there is a need to observe such a phenomenon during the total solar eclipse in 1999.

2. SOME PREVIOUS OBSERVATIONS

The first observations of low excitation spectral lines in solar corona were recorded in the last century (Dermendjiev, 1997). Namely, Rayet during the 1868 eclipse noticed H-beta, D, as well as 530.3 nm spectral lines high above the prominences. Also, Janssen on the occassion of the 1871 eclipse spectroscopically (radial spectroscope slit) found hydrogen emission lines 10' above the Moon's limb.

Later on, mainly in the first half of this century, some observers did not believe in solar origin of the recorded low excitation emission in corona. It was suspected to be the chromospheric radiation scattered in the Earth's atmosphere or, in some cases, it was found to originate in the telescope. Here we review some more or less successful observations where the recorded "cold" emission was supposed to originate in the solar corona.

Colacevich (1953) in the 1952 eclipse registered H and K CaII and H-gamma lines at a distance 70' from the Moon's limb explaining them as local appearance of a diffuse prominence matter.

Conway *et al.* (1967) using the airborne observed spectra analysed the variations of CaII lines with height in corona. Except being present at the base of the corona (in the chromosphere), these lines reappeared at one solar radius above the limb.

Near an active prominence, but not connected with it, Gurtovenko and Alikayeva (1971) in the 1970 eclipse observed low excitation emission 40 Mm to 100 Mm high in the corona. At the same position a system of thin, dense streamers was found. Elaborating the same obsetvation, Alikayeva (1975) found H, He and some neutral metal emissions and estimated the intensity of this "cold" emission as being about 1000 times weaker than in prominence spectra. She also evaluated a possible temperature value between 10^4K and 3.10^4K, as well as the electron density between $10^9 cm^{-3}$ and $10^{10} cm^{-3}$.

Bappu *et al.* (1972) observed coronal spectrum during the 1970 Mexican eclipse. As the most sriking low excitation spectral lines they found HeI 587.6 nm and H-alpha followed by the less intense lines H and K CaII, H-gamma,H-dzeta, H-eta and D3 with the maximum intensity at about 0.5 solar radii above the Moon's limb. The typical coronal lines FeXIV 530.3 nm and FeX 637.4 nm appeared closer to the Moon's limb. The authors readily explained the phenomenon as "a cool column in the outher corona" and gave a survey of observational arguments in favor of the coronal origin of those emission spectral lines.

Following the arguments of Bappu *et al.* (1972), Cavallini and Righini (1975) re-examined the coronal spectrum obtained during the 1963 eclipse by Deutsch and Righini (1964). Now, they carefully resolved the coronal components and paid attention to the intensity ratio of H and K lines of CaII. They were able to construct a model of cold (about 10^5K) coronal regions that can take size comparable to a coronal hole.

Kononovich *et al.* (1994) used the 0.05 nm passband Halle filter at CaII 393.3 nm during the 1981 eclipse. In lower corona he found an emission of the intensity 10 to 100 times larger then in the coronal continuum. The emission line had a larger height gradient.

Some years ago, a program for daily monitoring coronal H-alpha structures started at Pic-du-Midi (Niot and Noens, 1997). They use the Lyot coronagraph and a three-cavity interference filter centered at H-alpha with a 0.33 nm passband. The program is concentrated at rapid and energetic H-alpha structures very close to the solar limb - what is needed for coopearation with SOHO. It is also ready to record slowly-varying, low intensity phenomena high in the corona. As some exemplary results the authors presented rapid time-variations of H-alpha emission flux lasting from some minutes to one or two hours and amounting to from less than one to more than ten "sunbrightness in 1 arcsec square surface".

On the occassion of the 1995 eclipse in India, Bagara *et al.* (1997) obtained a good

H-alpha 0.075 nm passband filtergram covering about a quadrant of NE corona. In that portion of the outer corona they did not find any H-alpha emitting "pockets".

Most recently, Foing (1998) during the the 1998 eclipse searched for the cold H-alpha emission in corona. Till the time of submitting this text for the press, no results were published yet. However, he suggests to try such observations in 1999.

3. MODELLING THE REGIONS OF COLD CORONAL EMISSIONS

There are no conclusive theoretical results on the possible origin of low excitation (chromospheric) spectral lines high in the corona. Most often it is assumed that the phenomenon is a transient one - a special short phase in the very complex MHD activity in corona.

A picture of small-scale H-alpha emission regions in sporadic coronal condensations was presented in Orrall's discussion (1965). This is an empirical model of a sporadic loop-like coronal condensation. Generally, the high temperature (10^6K) loops are about 15 000 km thick and radiate in Fe XIV 530.3 nm. Imbeded in some of these are bundles of fine H-alpha loops with thickness of 2000 km and temperature less than 10^5K. In a thin transition region between these two components the red FeX 637.4 nm emission is radiated. The region that emits the yellow CaXV 569.4 line (always present in spectra of coronal condensations) is much more extensive. Orrall suggests that in such places the hot coronal plasma cools, compresses and produces small-scale H-alpha emitting regions. Life-time of that kind of coronal condensations is usually several hours.

One of potential physical mechanisms that might cool coronal plasma is given by Dermedjiev (1997) who in some detail describes the idea (earlier proposed by Öhman) that certain changes of local magnetic field in corona can sometimes decelerate electrons and protons spiralling around the magnetic lines of force.The result is local decreasing of kinetic temperature and recombination of hydrogen atoms. The effect is a temporary one and might last as long as a quasi-adiabatic state maintains.

4. A POSSIBLE OBSERVATIONAL PROGRAM IN 1999

It seems reasonable to propose the search for: a) Large H-alpha structures of any shape in the whole corona, and b)Tiny H-alpha bundles within Fe XIV 530.3 nm loops of sporadic (temporary) coronal condensations.

In the first case it should be the monochromatic imaging through a H-alpha filter having the passband between 0.3nm and 0.5 nm. The corona up to about two solar radii above the limb has to be recorded photographically (red-sensitive emulsion!) and with a CCD camera. One long-exposure of full size frame is desirable. Or two or more complementary images covering much of the corona can be made during the eclipse totality.

In the second case, the fine structure of sporadic coronal condensations in H-alpha can be revealed in high-resolution images recorded as filtergrams (as above) or as slit spectrograms. Here one has to predict the regions of corona where the sporadic coronal condensations are to be expected. The precise aiming of the telescope is essential. Long exposures would be also useful. Also, a simultaneous recording of FeX 637.4 nm and FeXIV 530.3 nm coronal spectral lines would help the interpretation of the H-alpha images.

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