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Some Structural Properties of Solar Magnetic Fields

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Abstract. We discuss some results of the study of spatial characteristics of solar magnetic fields. The analysis is based on the magnetic field data obtained with a new spectromagnetograph installed on the IZMIRAN Tower Telescope (Fe I 6302.5 Å) (Kozhevatov et al., 2002), the data of the MSFC solar vector magnetograph (Fe I 5250.2 Å) and the data of longitudinal magnetic 96 m daily maps of SOHO/MDI magnetograph (Ni I 6768 Å) downloaded through Internet. Our study was directed in some different ways: the fractal properties of sunspots; fractal properties of space distribution of the magnetic fields along great distances comparable with the size of active regions or active complexes; fractal properties of active and quiet regions as global entities. To do it we used some different methods, particularly, the well known method using the relation between the area and the perimeter of magnetic field lines (see (Feder, 1988; Meunier, 1999; Nesme-Ribes at al., 1996; Balke et al., 1993)) and technique developed by Higuchi (1988), who applied it to the investigation of long time series. Note also that magnetic structure in terms of the fractal models was developed earlier in (Zelenyi & Milovanov, 1991; Milovanov & Zelenyi, 1993; Mogilevskii, 1994; Mogilevskii, 2001; Abramenko et al., 2002; Abramenko, 2005; Salakhudinova & Golovko, 2005).

The main results are:

1. Fractal analysis of sunspot magnetic field indicated the existence of three families of self-similar contour lines roughly belonging to the umbra, penumbra and the ambient photosphere correspondingly. The greatest fractal dimension corresponds to the regions of weakest fields (ambient photosphere), the least one corresponds to the intermediate region (penumbra).

2. More detailed analysis shows that the fractal coefficient has a maximum (about 1.50) near the umbra–penumbra interface.

3. The global fractal numbers of space distribution of magnetic field on solar surface is closely connected with the mean absolute values of the longitudinal magnetic field for this surface. The fractal numbers diminish with the rising of mean magnetic field (from values about 2.0 for the relatively quiet region to 1-1.2 for very active regions).

4. The dependences of fractal numbers of the space distribution of longitudinal and transversal fields versus mean longitudinal field are similar by their character but the fractal values for transversal field are higher than the corresponding factor values for longitudinal field by factor about 1.5. This means that the distribution of transversal field along the space is more chaotic than the distribution of longitudinal field.

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References

Abramenko, V.I., Yurchyshyn, V.B., Wang, H., Spirock, T.J., & Goode, P.R. 2002, ApJ, 577, 487
Abramenko, V.I. 2005, Solar Phys., 228, 29
Balke, A.C., Schrijver, C.J., Zwaan, C., & Tarbell, T.D. 1993, Solar Phys., 143, 215
Feder, J. 1988, Fractals, Plenum, New York
Higuchi, T. 1988, Phisica D, 31, 277
Kozhevatov, I.E., Rudenchik, E.A., Cheragin, N.P., Obridko, V.N., & Kulikova, E.H. 2002, Instruments and Experimental Techniques, 45, No 1, 98
Mandelbrot, B.B. 1983, The Fractal Geometry of Nature, Freeman, New York
Meunier, N. 1999, ApJ, 515, 801
Milovanov, A.V., & Zelenyi, L.M. 1992, Phys. Fluids, 5(7), 1406
Mogilevskii, E.I. 1994, Sov. Astron. Lett., 20, N8, 607
Mogilevskii, E.I. 2001, Fractals on the Sun, Fizmatlit
Nesme-Ribes, E., Meunier, N., & Collin, D. 1996, A&A, 308, 213
Salakhudinova, I.L., & Golovko, A.A. 2005, Solar Phys., 225, 59
Zelenyi, L.M., & Milovanov, A.V. 1991, Astr. Lett., 17, 425