CONCLUDING REMARKS

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Recent interest in the subject of this discussion gained momentum by an observation which did not concern magnetic fields directly. The filigree which Dr. Richard Dunn on Sacramento Peak found 2 Angstrom off the center of H_α is a bright and crisp structure in the photosphere with a width of 1/5 arcsec. It was described in proper detail by Dunn and Zirker (1973). Even in the printed pictures in their paper one clearly sees one step beyond the solar granulation. The filigree is certainly related to the small scale structure of the photospheric magnetic field, but it is not yet clear whether the flux elements are exactly cospatial and have the same small dimensions. Simon and Zirker (1974) concluded from spectra that the field structure is wider than the filigree. On the other hand Harvey (1976) in his excellent review of the observations has also presented the arguments of several authors who conclude that the sizes of the flux elements are as small as those of the filigree. This discrepancy certainly needs further study before such even more delicate questions as the spatial extent of the downdraft inside and around the flux elements can be reliably answered from observations. The theoretical interpretation of the downdraft depends on this answer as different sources of the mass flow are involved: the overlying atmosphere and the convergent massflow of the surrounding convection. The latter stays partly outside the flux element, partly diffuses into it with an efficiency that might be enhanced by convection of still smaller scale.

Can the population of discrete flux elements be described as a family of axisymmetric configurations of meridional fieldlines with the flux as the sole parameter? Though this question has to be anwered by continued observations, there are at present no obvious other parameters which do or should interfere efficiently with such a description and we have heared e.g. Dr. Weiss clearly denying the need to invoke a twist in the theoretical description of any flux element

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during the discussion after his presentation. But does this family of flux elements have members all the way down to a radius wth optical depth unity in the horizontal direction or where else does it cease? This question is obviously related to the evolution of these elements. There must be a number of observable phenomena which constitute or are closely related to the steps of this evolution. The elements may originally appear in the photosphere either by vertical transport of compact fluxropes from below or by convective concentration of previously dispersed flux. Weiss (1976) in his review gave a beautiful quantitative description of the latter process which turns out to be extremely powerful. He derives a concentration of order square root of the magnetic Reynolds number way beyond the equilibrium between ram pressure and magnetic pressure. The only limitation he finds is set by the gas pressure of the surrounding photosphere. After its formation the element may migrate over the solar surface in a random walk forced by convection, it may coagulate with others of equal polarity into a larger element, it may coagulate with opposite polarity and disappear from the photosphere by reconnection and retraction up and down, and it may become unstable and fall apart into smaller elements or transmute temporarily into totally dispersed flux, e.g. at the lower end of the range of fluxes. But it may not retract below the photosphere together with all the connected atmospheric flux including the corresponding opposite photospheric flux element since there is neither sufficient energy nor sufficient coherent downward motion in the observable flow pattern above the solar photosphere. There seems to be no alternative to reconnection very near to the photosphere as the final fate of any photospheric flux. On the other hand it is an open question how often and how long any compact flux changes into a totally dispersed state.

There are also several different possibilities to define a lifetime of a flux element. The time it takes for an element to migrate far enough to escape observable correlation with its origin may be smaller than the time it takes to fall apart or to disperse or to coagulate with equal polarity and those times may be still much smaller than the time it takes to disappaer completely from the photosphere by reconnection and it may take another length of time til any flux element is connected into interplanetary space by the solar wind. Such types of processes and their timescales must be deduced from observation in order to construct a consistent picture of the evolution of photospheric flux elements.

In all these necessary investigations observations of high accuracy are needed and such accuracy can only be proven by tests. Some such tests may be provided from theory. The sourcefree character of the magnetic field may be used for such a test if the net flux is integrated over an observed area as a function of time. This net flux will not exactly vanish initially but it should change with time only by migration of elements across the boundaries and by emerging flux which appeares on the boundaries themselves. Another example is the limitation of the photospheric field at the surface of an flux element by the photospheric gas pressure.

In closing let me emphasize my enthusiasm ror the new observations we have seen. They have shown some exciting new land beyond the arcsecond. We ought to conquer it. And if I look at some of the new tools which are now forged in the numerical treatment of convection and radiative transport at intermediate optical depth, I think we will.

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