Long-term optical studies of cataclysmic variables

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Summary

In this thesis the results are described of a study of cataclysmic variables; these are binary stars, in which one of the two components transfers matter to its companion star, due to gravitational force of the latter.

The star that receives the matter from its companion is a so-called white dwarf (if the mass-receiving star is a neutronstar, we are dealing with a low-mass X-ray binary). The mass of this white dwarf is approximately that of the sun, and its radius comparable to that of the earth; the gravitational potential well into which the matter falls is therefore so deep that a large amount of gravitational energy is released and radiated away. The matter transferred from the companion star spirals inward onto the white dwarf, as a consequence of which it forms a disk around the white dwarf.

The brightness of many of these binaries, which is mainly determined by the above release of gravitational energy does not appear to be constant, but to change strongly (by a factor of 10 to 100) on a rather short time scale (of the order of days). These changes are the result of a change in the amount of matter that reaches the white dwarf per unit of time.

To describe the origin of these so-called dwarf nova outbursts two kind of models have been proposed; in one model the outburst is caused by an instability of the mass-losing companion star, in the other model this instability occurs in the disk around the white dwarf, through which the matter flows inward.

These models for outbursts also make different predictions regarding the quiescent behaviour of dwarf novae between outbursts. In the first type of models one expects that, on average, the brightness between outbursts remains constant; the second type of model predicts that the brightness then shows a steady increase. In chapters 2 to 4 of this thesis an observational study is described of the brightness behaviour of dwarf novae between outbursts, with the aim to test these theoretical models on the basis of the above-described difference. The result of this study is, that the observations are difficult to fit within the disk-instability model.

In a small group of cataclysmic variables the white dwarf has a strong magnetic field. This field prevents the infalling matter, before it reaches the white dwarf, to form a disk, but forces it to stream along the magnetic

field lines, until it reaches the white dwarf at its magnetic poles. The radiation received from these polar regions is modulated, as a consequence of the rotation of the white dwarf.

Matter that reaches the surface of the white dwarf, or is connected to the magnetic field of the white dwarf, excerts a torque that leads to variations of the angular velocity of the white dwarf. Only in the magnetic systems can we observe these changes, as the rotation period can be measured.

In chapters 6 and 7 of this thesis a long-term study is described of these magnetic cataclysmic variables, with the aim to detect such changes in the white-dwarf rotation period. It appears that some white dwarfs spin up, and others spin down; in addition the time scales of these spin-rate variations are much shorter than the evolutionary time scale of the binary. This indicates that there are large variations in the mass-transfer rate, on relatively short time scales.

The long-term observations of cataclysmic variables also led to some surprises. In the first place (see chapter 5), it appears that during a special kind of dwarf nova outburst (the so-called superoutbursts) the spectral colours in the system VW Hyi vary in an, as yet, unexplained way. In the second place, the observations showed, that outbursts occur not only in the dwarf novae, as so far seemed to be the case, but also, and regularly, in the magnetic systems. These outbursts in the magnetic systems look different from the dwarf nova outbursts (these last shorter and are less intense), which can very well be due to the fact that the magnetic field of the white dwarf prevents the formation of (at least) the inner parts of the disk. These results are described in chapters 8 and 9.