Mem. S.A.It. Vol. 83, 876

Memorie della

The Golden Age of Cataclysmic Variables – 50 Years of CV Research – A Workshop Summary

Edward M. Sion

Department of Astronomy & Astrophysics, Villanova University,
800 Lancaster Ave., Villanova, PA 19085, USA

Abstract. When Franco asked me to present a summary of this conference, I answered yes, almost without hesitation, not realizing the daunting challenge posed by the emergence of so many exciting new results. Obviously, this summary contains impressions of the workshop viewed through my own prism. Let me begin on a personal note, by stating that I cannot imagine any venue for a conference on Cataclysmic Variables more striking than Mondello. The overall description of the conference that comes to my mind is: masterfully organized, comprehensive, up to the minute, new science in a wonderful and historic setting of nearly unmatched beauty.

The stage was set for the conference by outstanding, comprehensive reviews of cataclysmic variables, the first one covering the past "Golden Age" of fifty years by Franco Giovannelli. This provided the participants with a thorough historical perspective on how the field evolved to its present state of knowledge. This was followed by another excellent review by Andrew King on Accretion Disk theory since Shakura-Sunyaev , delivered with the clarity we have come to expect. Hans Ritter's talk on the Structure and Evolution of Cataclysmic Variables enriched the participants with still another outstanding overall review. Among the many highlights in both theory and observation that I found particularly outstanding were two breakthrough numerical simulations. I was blown away by the ever more physically realistic theoretical simulations presented by Dmitry Bisikalo and Irit Idan. The 3D magnetohydrodynamic simulations by Bisikalo offered detailed comparisons with observations of the accretion environment and complex flows in cataclysmic variables with magnetic WD accretors, including the physical interpretation of phase dependent structures and asymmetries in gas flows around the white dwarf primary and its application to both Roche-lobe overflow systems.

The 1D evolutionary hydrodynamic/quasi-static simulations of accreting white dwarfs in cataclysmic variables undergoing nova outbursts, presented by Irit Idan, cover the response of the white dwarf to thousands of these thermonuclear events over timescales up to a billion years or longer. While these long term evolutionary sequences are being carried out with a constant accretion rate, her code can be easily modified to handle variations in the accretion rates due to changes in the rate of an-

Send offprint requests to: Edward M. Sion (edward.sion@villanova.edu)

gular momentum loss versus time. It appears that such sequences will ultimately provide strong constraints on scenarios of CV evolution, above and below the period gap.

The ongoing debate revolving around the disk instability model (DIM) versus mass transfer instability (MTI) as the mechanism for dwarf nova outbursts found center stage at this workshop. Jean-Pierre Lasota delivered a stimulating talk on the present state of accretion disk theory but with a dose of skepticism concerning the mounting evidence which challenges the validity of the disk instability model (DIM) and the use of the alpha viscosity. On the other hand, Oded Regev reminded the participants that it is okay to use the alpha viscosity, that there is no need for apologies in doing so since magnetohydrodynamic turbulence is too complex to understand and currently insoluble. Adding fuel to the fire, Raymundo Baptista reported eclipse mapping analyses of light curves of the eclipsing dwarf nova HT Cas which revealed a very fast response of the underlying white dwarf (which brightened by a factor of 2) to the increase in mass transfer rate, a simultaneous increase in the expansion rate of the accretion disk (which brightened by a factor of 3) and a relative amplitude of the high-frequency flickering which implies a high viscosity (alpha 0.3-0.7) for the quiescent disk and hence disagrees strongly with the key prediction of DIM. His work suggests that the outbursts of HT Cas may be due to bursts of enhanced mass transfer from the donor star, i.e. the mass transfer instability.

Speaking of dwarf novae, no less than four talks, and portions of two other talks (the equivalent of one full session), were devoted to the prototypical dwarf nova SS Cygni and its associated puzzles by Franco Giovannelli, Dmitry Kononov, Manabu Ishida and Irina Voloshina. Franco presented a list of pros and cons on the issue of whether SS Cygni is an intermediate polar. He concluded with compelling evidence that SS Cygni is indeed an IP with a likely 2,000,000 Gauss field, and hence should have a truncated accretion disk. Since among single white dwarfs, there is a continuum of field strengths from multi Megagauss fields of the class of magnetic degenerates to weak multi-kilogauss field regime at the threshold of detection, it would not be surprising that, at some level, every white dwarf in a CV is magnetic. Irina Voloshina further underscored the complexity of SS Cygni by discussing its three types of outbursts; normal, long, and anomalous, as well as its QPOs, DNOs and flickering. She also discussed a newly derived white dwarf mass estimate of 0.66 $M_\odot$ and an orbital inclination of 50 degrees. The mass quoted above is lower than the white dwarf mass of 0.81 $M_\odot$ derived by Bitner, Robinson and Behr (2007) and much lower than the widely used value of 1.2 $M_\odot$ derived by A. Shafter from disk emission line velocities. Irina Voloshina's determinations are also in disagreement with the values of the white dwarf mass of 0.97 $M_\odot$ and orbital inclination angle of 40 degrees, obtained by Giovannelli et al. (1983) using physical constraints derived from multifrequency observations. Interesting new results on SS Cygni from SUZAKU were presented by Dai Takei, including X-ray observations of SS Cygni in both outburst (multi-temperature plasma) and quiescence (Fe emission lines at 6.4, 6.7 and 10 keV) and a derived Fe abundance of 0.37 x solar. Kononov obtained tomograms of SS Cygni that he directly compared with 3D gas dynamic simulations including the hot line, tidal shock spirals and a bow shock where trailing matter accumulates behind the shock, which accounts for an observed asymmetry.

Still another complex CV, the unique IP, AE Aquarii, was the focus of three speakers, Pieter Meintjes, Chris Mauche and Robert Smith. Meintjes reviewed the physical and orbital parameters of AE Aqr, as well as multiwavelength observations spanning the Gamma-ray and X-ray region out to radio wavelengths. Due to the operation of a magnetic propeller, many argue that the white dwarf is accreting very little matter but the mass leaving the system is significant. The system exhibits the N/C abundance anomaly indicative of CNO processing. It is clear that the white dwarf is spinning down but what is extracting its rotational kinetic energy? It may have evolved to its present state from a violent accretion history which may link AE Aquarii to the supersoft X-ray binaries. Chris Mauche delivered an interesting review of multiwavelength observations of AE Aquarii and presented evidence refuting that it is a Gamma ray source.

S. Scaringi presented breathtakingly precise Kepler data and light curves of CVs in the Kepler field, including V344 Lyra with evidence of positive and negative superhumps and an outside-in outburst. For the VY Scl-type nova-like variable MV Lyr, Kepler recorded flickering intrinsic to MV Lyra's accretion disk. Scaringi reminded us of the remarkable similarities between the flickering behavior in CVs like MV Lyra and X-ray binaries containing neutron stars and black holes, which show similar behavior. The common thread among this flickering may be a fluctuating accretion disk. In a stunning demonstration of Kepler's photometric precision, he displayed accretion disk fluctuations superposed on each other, from different accretion disk radii; i.e. Kepler is probing dynamics within the accretion disk.

Classical Novae and the supersoft X-ray phase of their outbursts were covered extensively in both theory and observation via superb talks by Massimo Della Valle, Mariko Kato, Margarita Hernanz, Nir Shaviv and Elena Mason. Nir Shaviv discussed classical novae in the context of super-Eddington steady state winds which, at peak luminosity, can dominate the evolution of a classical nova outburst over continued thermonuclear burning. He pointed out numerous examples of super-Eddington steady states among the novae in M31. Mariko Kato also discussed wind outflow from novae, pointing out that the putative optically thick winds are not line-driven but rather driven by radiation pressure gradients. Massimo Della Valle presented the classification of nova light curves by speed class versus nova progenitor properties and population membership as well as reviewing the characteristics of two broad composition classes, the Fe II class and the He/N, the latter being faster novae with more massive white dwarfs while 82

There were outstanding comprehensive reviews by Klaus Reinsch on multi-frequency observations of polars, by Solen Balman on the X-ray properties of cataclysmic variables in general and by Martine Mouchet of XMM-Newton X-ray studies of magnetic CVs. I was also intrigued by Takayuki Yuasa's discussion of the determination of the masses of white dwarfs in intermediate polars based on SUZAKU observations. A mean mass of the white dwarfs in IPs was derived $< M_{wd} > = 0.88 \pm 0.2\ M_{\odot}$.

Paula Szkody described her work on identifying the instability strip for accreting white dwarfs in CVs which undergo non-radial g-mode oscillations. She showed evidence that an accretion event like an outburst or super-outburst can heat the white dwarf, moving it out of the instability strip but then as the white dwarf cools, it moves back into the strip. Her observations make it possible to apply the techniques of asteroseismology to the probe the interior structure of accreting, rotating CV white dwarfs.

In summary, this was an extraordinarily stimulating, well-organized workshop in every respect, covering virtually every aspect of cataclysmic variable research in both theory and observation. The organizers, particularly Franco Giovannelli, and the Local Organizing Committee are to be highly commended for the excellent job they did in helping to make this workshop a resounding success.