To my grandfather Mario

and to all my friends and relatives

who in these three years have crossed

the Last Event Horizon

“We were now in the belt of breakers that always surrounds the whirlpool, and I of course thought that the subsequent moment would have thrown us into the abyss, the bottom of which we saw only faintly because of the fantastic speed at which we were driven around.” (from: Poe 1839)

ABSTRACT

X-ray Novae, or Soft X-Ray Transients, form a sub-class of Low Mass X-Ray Binaries and are characterized by a sudden increase of the luminosity over the whole electromagnetic spectrum. These paroxistic events are currently interpreted as the consequence of one or more violent episodes of accretion from a low mass star onto a compact object, the outburst at optical wavelengths being the more evident signature of the reprocessed emission from the accretion disk irradiated by the X-ray outburst.

The study of the optical counterparts of these X-ray objects is of great importance because in 7 cases it has been found that the mass of the compact object exceeds the maximum stable mass for a neutron star, thus pointing out X-ray Novae among the most suitable targets to probe the existence of black holes.

This Ph. D. Thesis will deal with this class of objects in two ways: by analysing the optical data of four single X-ray Novae observed during the outburst phase, and by gathering the most important quiescent and outbursting features of all the objects which belong to this class. The aim of this Thesis is then to find out the general properties of the class of X-ray Novae.

In the following, the general scheme of this work is given: after three introductory chapters (Ch. 1 will summarize the theory of accretion, Ch. 2 will describe the accretion disk instability and the phenomenology of Cataclysmic Variables, and Ch. 3 will talk about X-ray compact objects, with the emphasis on X-ray Novae) the results of the spectrophotometric data analysis concerning four different X-ray Novae during the outburst will be presented in Chs. 4, 5, 6 and 7; finally, Ch. 8 will analyse the characteristics of outbursting and quiescent X-ray Novae and will draw the conclusions.

The results of Chs. 4, 5, 6 and 7 have been published on *Astronomy & Astrophysics*, while those coming from part of Ch. 8 have been published on the on-line journal *New Astronomy*.

INTRODUCTION

So let me introduce to you
The one and only Billy Shears
And the Sgt. Pepper's Lonely Hearts Club Band!
(Beatles 1967)

The study of the X-ray emission from the Universe has reached in the last decade a fundamental astrophysical importance, as it allows the analysis of the behaviour of matter in extreme conditions of temperature, velocity and density. In particular, the observations of point-like X-ray emitting sources and of their optical counterparts permits the study of the nature of extremely compact objects, such as neutron stars or black holes harboured in binary systems and accreting from an ordinary matter star which loses mass via stellar wind or gravitational instability.

X-ray Novae, or Soft X-ray Transients belong to this class of objects. The great astrophysical interest for these latter systems which grew in these last years is due to the fact that these objects show all the characteristics of accreting black holes and, in 7 cases, a spectroscopic confirmation to this statement has been found. Therefore, observations performed all over the electromagnetic spectrum on such systems during the outburst and quiescence stages allow an accurate analysis of the nature of these collapsed object, which are among the most mysterious elusive in the Universe.

The aim onf this Ph.D. Thesis is then to reach a deeper knowledge of X-ray Novae by the study of the optical counterparts of 4 of these systems during the outburst phase, and by the analysis of the main properties of this class of objects as a whole thanks to the use of the published data on each of these systems. Particular attention has been devoted to the application of alternative methods, with respect to optical spectroscopy, for the determination of the mass and of the nature of the compact object already in the early outburst phases. An entire chapter has been dedicated to each of these studies. These chapter are self-explanatory, but also are integrated in the wider context of this Thesis.

The work has however been structured in order to be understandable also to the reader who is not familiar with the “X-ray binaries” subject; this has been possible making use of a wide introducive section.

Going into details, Chapter 1 is devoted to the description of mass transfer phenomena in a double system and of the formation of an accretion disk; Chapter 2 illustrates the instability mechanisms in disks and the systems in which this instability happens when a white dwarf is accreting, while Chapter 3 introduces the systems in which accretion takes place onto a neutron star or a black hole, with articular attention to the X-ray Novae phenomenology. Chapter 4 to 7 deal with the analysis of observations of 4 X-ray Novae during the outburst phase, and Chapter 8 presents a statistic study of the general properties of this class of objects.

Moreover, 6 Appendices are reported, which contain, in sequence, the description of a simple informatic code for the simulation of lught curves of X-ray Novae at maximum light, a short review of the main X-ray emission mechanisms, a fast introduction on methods of time-series analysis used within this Thesis, the finding charts of the X-ray Novae known so far, the physical and mathematical constants which appear in this work and, finally, the journal papers in which the Ph.D. work has been presented.