A MONTE-CARLO SIMULATION OF CELESTIAL X-RAY TRANSIENTS

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April 19, 2003

Chapter 1

Introduction

The Scanning Sky Monitor aboard ASTROSAT aims to monitor the transient sources in the sky. Majority of the X-ray sources are transient in nature and modelling them is of immense importance. These sources have been monitored and the data in the form of light curves are present in day to day basis or dwell by dwell format. These light curves are the data which are fit and then used to derive the model of the transient sky. The QDP interface is chosen to fit the curves and the programmes are either written in 'PERL' or in 'C' language.

1.1 Preprocessing

The data extracted from the RXTE Catalog in the raw format has to be appropriately preprocessed for specific usage. In the present case we smoothen the data by averaging over a fixed time step. The data is smoothened to facilitate a better visualization and to pick the right bursts. An appropriate window size is obtained by choosing the best among the different window sizes that are tried to smooth the data. To smoothen the data one of the algorithms that are described below is employed.

1.1.1 Box Average Method To Smooth Data

The light curves observed for a specified period of time are used. From the data available the time of observation and the sum-band intensities and the error on the intensities are extracted. This data is then binned in discrete steps of time and a average value for sum-band intensities are calculated within the window. The boxavg.c (sat2:astrosat:arun) code reads the data (time of observation and the Sum band intensities) and then bins the data using a user specified bin size (in MJD). The data is then written into a file with a "inputfile.box" extension which is the smoothened data.

1.1.2 Window Average Method To Smooth Data.

In the window average method the time of observation, sum-band intensities and the error on the intensities are extracted from the data file and unlike the box average method the data is averaged in a user specified window size but not in discrete steps.The data in the window width is averaged and is written in the position of the average value of the data within the width. The window is then slided by one data value and the procedure is repeated until one covers the whole data and smoothens it. This will ensure that we do not smooth the data coarsely. The winavg.c (sat2:astrosat:arun) programme slides a user defined window size and performs the task of smoothening data.

Note: The window average has not been performed for any of the sources.

1.2 METHODOLOGY

A few representative sources from the RXTE Catalogue are shortlisted and their light curves are then extracted. This data is smoothened either using the box-average method or the window average method. The preprocessing algorithms' return the time of observation the sum band intensities and the error on the intensities. These values are plotted using the QDP interface.
A specific source from the RXTE Catalog is chosen . Each source chosen goes through the following steps to derive its characteristics .
Step1. The data is smoothened using a appropriate window size. The smoothened data is then generated. The data is plotted in the QDP interface.
Step2. Each plot is then scaled in ranges and manually visualised for a particular sigma level . For the specified sigma level bursts are identified and a appropriate fit model available in the QDP library are used to fit the data see figure1 for example. The procedure is repeated so as to fit the complete range for which the source is observed. The best fits once obtained returns the fit parameters which are then used to write a database file which is a log of all such best fit parameters.
Step 3. A database file so created consists of the following information. Source file preceded by the special character which facilitates its recognition then the total number of outbursts in the source for the period of time it has been observed and fitted then the type of averaging along with the width of the window that has been employed.The various models that are used to fit the source. The file also describes the individual outbursts and their ranges. The fit parameters follow this description.(see database.dat(sat2:astrosat:arun)).

The procedure is repeated for a different source and the database file is updated to include the characteristic parameters of all the sources shortlisted.

1.3 REPRESENTATION

To demonstrate if the fit parameters obtained are correct we try to fit the data automatically using a awk programme. The awk programme uses the database file and the fit parameters in the file to plot the whole data along with the fit automatically. The awk programme accepts from the user a particular source name which is already manually fitted and searches the data base file for the source and reads the first line which consists of the information of the smoothing procedure, smoothens the data accordingly. And using the fit parameters from the database file plots the smoothened data along with the fit. auto.awk (sat2:astrosat:arun).

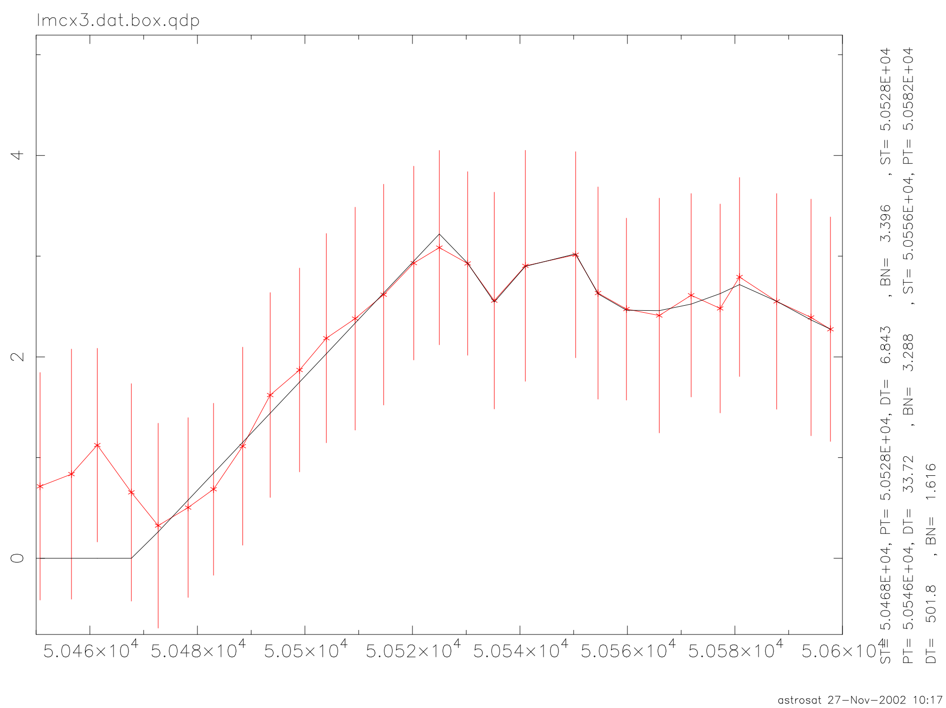

Figure 1.1: fig 1 .FIT FILE

Chapter 2

MODELLING PARAMETERS

Seven of the sources that are already shortlisted is fitted and the fit parameters obtained are written in the database. The average values of these risetimes, decaytimes, binnormalization and the burstwidth's are obtained by following the procedure described below.

Statistics
The database file is read by a perl programme which generates a statistics of all the burst . The per.pl(sat2:astrosat:arun) programme returns the risetimes, decaytimes,binnormalization and burstwidth of all the bursts manually fit .The program reads the databasefile and for every burst that has been manually fitted extracts the burst parameters and writes them into separate files. A file containing all the rise times(raise.dat), decay times(decay.dat) and binnormals(bnormal.dat) are obtained.

These statistics are then binned using a histogram programme(histogram.pl) which reads the risetime file separately and averages it with a user defined bin size.The decaytime files and the binnormalization files are also binned following the same procedure. The data obtained is plotted and a Gaussian fit is obtained for each of them separately.For each of the fits the values of Gaussian center, Gaussian width and the Gaussian height is generated. These fit parameters are the representatives of the parameters which go-in to model the Transients. A fit of the parameters so obtained are then used to simulate the rise decay and bnormalisation values of bursts.

2.1 TRANSIENT MODEL

The model in the present form uses the data generated for the statistics obtained by modelling a few chosen representative X-ray sources.A Monte-Carlo simulation technique is employed to model the transient sky.
The program (sushila.c (sat2:astrosat:arun)) is a function that returns for a specified calling time simulates the bursts and returns fluxes and positions of 150 sources to the user at that time from a reference time. The different steps involved in deriving the bursts is described below.
Step 1
A random value for start time in the range of average burst frequency is generated, Initially reference time is set to zero. A time from the user is input to call the function. If

the difference of time and reference time is greater than start-time a burst is generated.
Step 2
Once a burst is generated a Monte-Carlo simulation technique using the parameters obtained by fitting the risetimes of all the manually fitted bursts is used to generate a rise time for the burst. The decay time and the binnormalization value is also simulated using the respective fit parameters. A random position of ra and dec is also generated for the burst simulated. The Ra is a random number in the range of 0^o to 360^o and dec is generated using a sintheta distribution function in the range of -90^o to $+90^o$.
Step 3
To obtain the flux value of the burst simulated at the time of call the flux value at that time is found using the straight line equation of the risetime if the time of call is less-than starttime and greater than peaktime. If the time greater than peaktime and less than endtime a exponential function is used to generate a flux value for the burst.
Reset the reference time to the starttime if a burst is generated.
Step 4. For every such call a array of 150 parameters are returned. If at any value of calltime the 151'st burst is generated from the starttime the first burst is replaced by the values generated for the newly generated burst. The newly generated burstparameters are upgraded and these values are returned. The fluxes so generated are plotted on the aitoff at the randomly generated positions.

2.2 GRAPHS

The output of a trial run to simulate the bursts returns the flux of 150 values of serial number and the positions for a specific time is generated in the trial conducted 600 trials were generated. A plot of fluxes versus time for a particular serialnumber(range 0 to 150) varied in steps of 9 is plotted. These plots are generated using a plot.pl(sat2:astrosat:arun) programme which accepts a value for serialnumber from the user and returns all the possible flux generated at different intervals of time for the specified value of serialnumber.These plots have been shown in the log book page 27.
A plot of fluxes versus serialnumber for a specified time is plotted by varying the time (range in the example case 0 to 600) in steps of 25. These plots are generated using the plot1.pl (sat2:astrosat:arun) programme which that accepts a time and generates fluxes for all the serial numbers for a user specified time. These plots are generated and are shown in the log book page number 29.

2.3 AUTOMATING THE PROCESS OF BURST IDENTIFICATION

The model obtained by simulating the bursts from a statistics of a few representative sources is not robust. To improvise on the model one has to consider all the sources and their statistics need to be included. To manually fit all the sources it is cumbersome and time consuming. Hence a algorithm has to be developed to automatically identify the right bursts and then return their statistics. The method has to involve a way to find the sigma level specific to source and then identify all the bursts above the calculated level.

A iterative process to remove the rms value of the baseline is included to first find the sigmalevel. All the bursts above 5 times rms value are identified and reported. To avoid false peaks in cases such as a sudden rise in only one data point fron a low value. The rms value is generated after smoothening the data using box average method

A file consisting of all the source names is created. The box averaging programme reads the file as the input extracts the source name from the file and the data for that source is box averageg for a specific window size. The output, the smoothened data is written into a file with a ".box" extension. The procedure is repeated for all the sources present in the file. The result of the programe is all smoothened files with the ".box" extension. A file which consists of all the ".box"extension are then put into a file which is used in the statistics programme. to generate the statistics from the box averaged data a source is selected from the list of sources that have been smoothened and then it is run through the stat.pl programme which accepts the smoothened data and first replaces all the data values which are less than the sigma level to zero. All the other data points are read and if there are more than 4 datapoints between successive zero values it is identified as a burst and is reported the peak flux is found using the max value for the sum band intensity at that range. The criterion of a minimum of four points to be present will ensure that the false peaks will not be reported. The programme identifies all such peaks and generates the peak value (local peak), the width of the peak and the average burst frequencies are also calculated. The programme is checked for a few trial sources and then checked for consistency. To run it through for all the sources and include their statistics a file consisting of all the smoothened files is created and the procedure employed in the single source case is extended for all the sources.

The perl programme totalstat.pl (sat2:astrosat:arun:RXTECatalog) reads the data downloaded from the RXTE Catalogue. Appropriate fields time and sumband intensities are extracted from the set. The file "statinputfile" which contains all the sourcefiles with the ".box" extension is read line by line which implies source by source and generates all the required statistics of the particular source and reports the results in to a file. The procedure is repeated to include all the sources(See statoutputfile). The statistics are then used to find the average of all the fluxes and burstwidths and average burstfrequency which are then incorporated to generate a robust model of the transient sources. The plots of the results after automating the process of identification of the burst are checked for the sources that are already fit manually to check for correctness. The plots of the source smcx1 is shown in fig2.

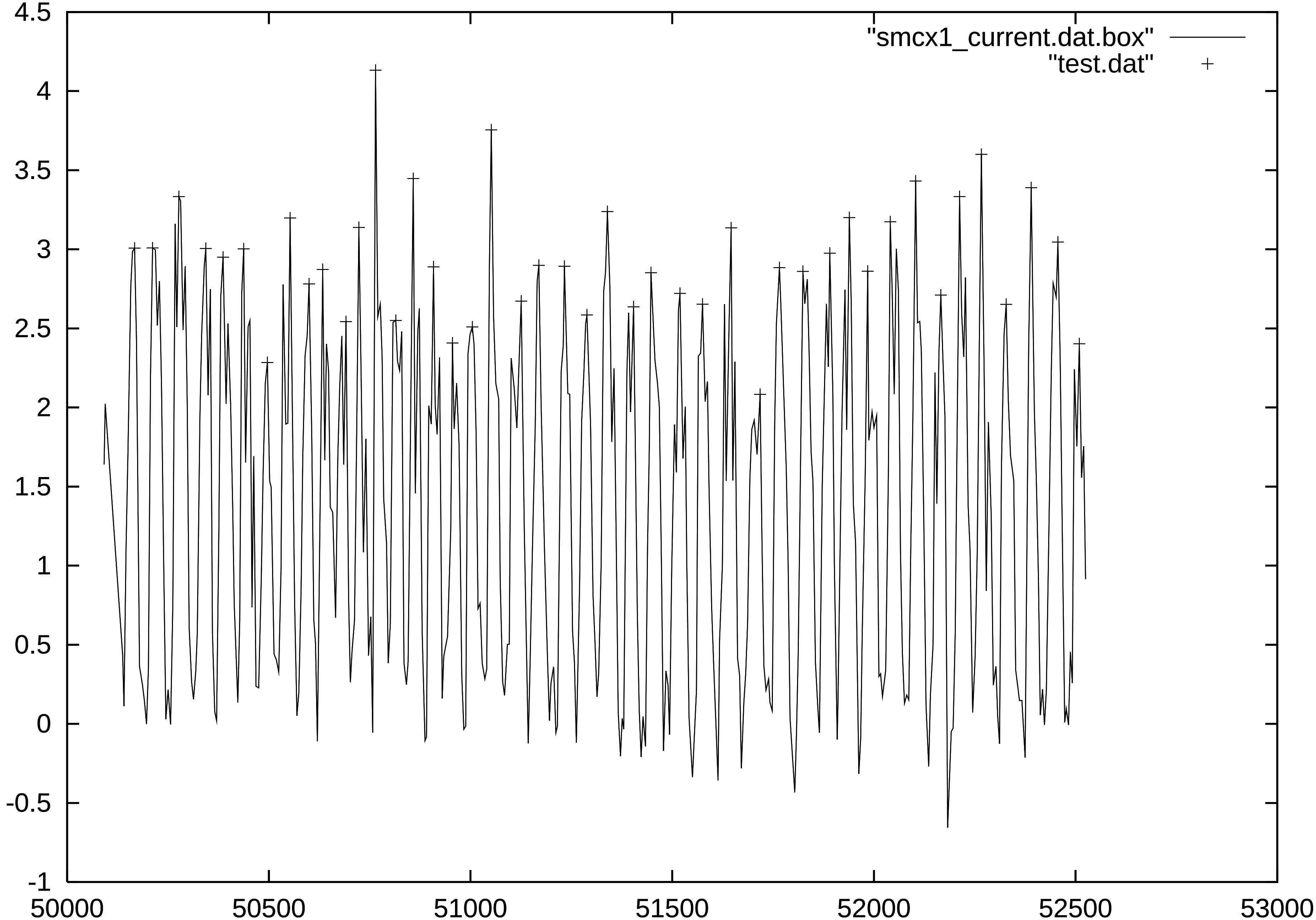

Figure 2.1: Automated Output