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Historic Spectra of Exotic Objects at your Fingertips: Raking up their Past

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Abstract. Astronomers possess a heritage of enormous wealth and potential: historic observations detailing the foundations of astrophysics, witnessing the observable universe decades ago, and recording any number of periodic or sporadic phenomena. If those observations were available on-line, what an enormous resource they would constitute for research. But they are not; they are on non-digital photographic plates, and we risk losing all that information for ever unless some measures are taken fairly soon to transfer it digitally to a more accessible medium.

1. The importance of studying changes

Scientific wisdom advances on two fronts: by analysing observations in terms of what they reveal about the object, and by modelling (synthesising) the observations on the basis of known physics. However, modelling can produce ambiguous results or, unbeknown, the right result for the wrong reason. One particularly stringent test of a model is its ability to predict changes. Hence, the more observational evidence of changes that we can bring to bear, the more completely we should be able to explain and eventually model astrophysical phenomena.

Many changes are long-term. Some (e.g. hot-spots, chromospheric eclipses) are associated with stellar duplicity, and their frequency is geometry-specific rather than physics-specific. For events with periods greater than a few years, observations of past occurrences are our only means of refining the period, or of determining whether period modulations or fluctuations are present. Other changes (e.g. shells and nova outbursts) involve processes that are inherently long-term. Observations of many different cases, and of past events in the same object, provide essential, often the principal, keys to understanding the processes that are taking place.

Archived data are therefore a prime resource for these important aspects of astrophysics. In many cases they may be the only route to the information necessary for such research.

2. The bizarre, the enigmatic, or the plain variable

Several highly bizarre objects manifest changes over such long intervals that little inroad into understanding the nature of their peculiarities can be achieved from observations covering only a few months or a few years. Examples include:–

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- The decades-long enigmatic behaviour of η Car, ϵ Aur, FU Ori
- Born-again AGB stars like FG Sge
- Long-period variables, novae outbursts, supernova shell remnants
- Transient events, never to be re-observed (helium flash; supernova)
- Polaris, the Cepheid which stopped ticking
- Chromospheric eclipses of 31 Cyg ($P = 10.5\,$y)
- Pan-orbital changes in VV Cep ($P = 20.2\,$y) and KQ Pup ($P = 26.7\,$y)

3. Another side of astronomical progress

Variable objects have been recorded spectroscopically by numerous observers for short spans during different decades and the observations have been archived, but few researchers can tap the information today because the observations are on non-digital photographic plates. For VV Cep alone there are hundreds of DAO coudé spectra which have never been digitized, and which can therefore not be used, amassed or shared in modern research.

Modern technology has been unkind to research into long-period phenomena. It offered us the CCD before it furnished us with assured methods for storing and recalling our digital observations. Only those able or wise enough at the time to transfer magnetic-tape observations plus the associated reduction software to other media will today be able to refer rapidly, easily and with confidence to observations made as long ago as 1980.

But Astrophysics did not start in 1980. Observers were active at least 100 years before.

Why can't we access all the spectroscopic observations of the 20^{th} Century? *If only* we could access what we want instantly ... *If only* we could incorporate those spectra into modern software ... *If only* we could browse historic archives and get inspirations from the wealth of what is there ... *If only* ...

4. The Spectroscopic Virtual Observatory

4.1. The need for a rescue mission

The situation today is giving increasing cause for concern. Few archives are stored in anything approaching ideal conditions; photographic emulsions slowly deteriorate with time, and the effects of emulsion aging are not reversible. Even more threatening is the impact of human indifference. The longer the plates remain stored but unused (and effectively unusable by the vast majority of researchers), the more likely it is that they will eventually be discarded in order to release space for some other activity.

4.2. An international initiative

Spurred on by these impending hazards, the *IAU Working Group for Spectroscopic Data Archives* is trying to set up a laboratory to digitize important selections of the world's archived photographic spectra, giving highest priority to coudé spectra and to anything of relevance to studies of long-term variability.

The objective of the project is to rescue as much of the information as possible from spectroscopic plates before it is too late, and to render it fully accessible to the community in ready-to-use form so that the archives can be efficiently and effectively mined.

The project will be developed at the DAO in Canada, where laboratory space has been offered. We plan to install two, possibly three, PDS or other microdensitometers, suitably upgraded with high-precision, high-speed recording capabilities. We will first scan the DAO's own coudé collection and selected spectra from its older cassegrain archive; we will then arrange to borrow selected spectrograms from other archives.

The spectra we scan will be fully intensity- and wavelength-calibrated. All the extracted spectra will be made available world-wide via the CADC Website. The entire database of historic spectra should be accessible by the National/Global Virtual Observatory.

For further details, please visit http://herbie.ucolick.org/public/svo.

4.3. Contents Catalogues

One essential task, preliminary to scanning an archive, is to create an on-line catalogue of the contents. The individual contents catalogues will eventually be merged, to form a master catalogue that retains the identities of the observatories of origin, as well as other pertinent details. If some of this cataloguing can be carried out at the home observatory, that will greatly assist the project.

5. Pilot study: Time-dependence of stellar chromospheres

In a pilot study, chromospheric-eclipse spectra of (a) 31 Cyg, observed at the DAO and Calar Alto in 1972 and 1993 and (b) ζ Aur, observed at Mount Wilson in 1939/40, 1947/8 and 1955/56, have recently been digitized. The chromospheres of both prove to be anything but constant or homogeneous (see Fig. 1), and that condition presumably affects the stellar winds which originate in those layers. Measurements of the changes should assist our understanding of the physics of the stellar winds.

The quality of even the oldest plates is encouragingly good. We are not yet too late. The data can still be rescued. They can be used to complement and enrich investigations based on modern data, and to open a route to new studies that concentrate entirely on long time-dependences. We are fortunate indeed that our predecessors took pains to preserve their archives of observations for our use, and it will be to our everlasting shame if we fail to provide what it takes to preserve the information in those archives appropriately for our own posterity.

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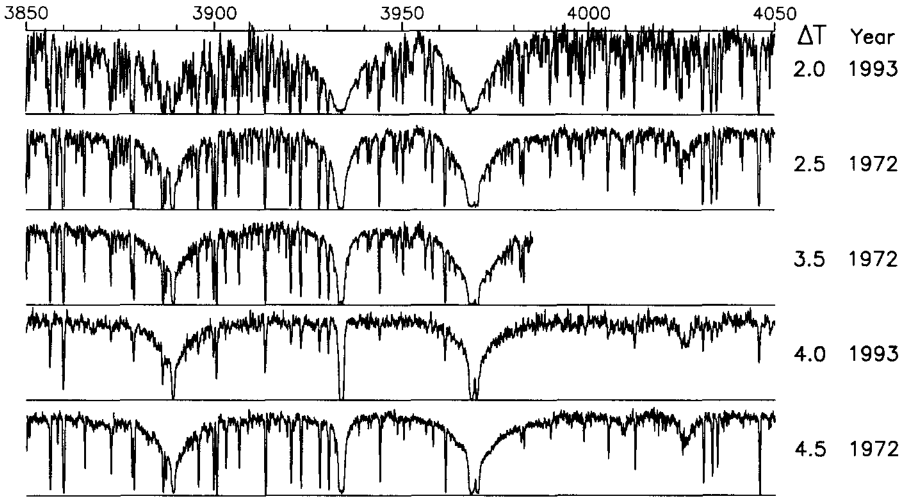

Figure 1. Extracted spectra of 31 Cyg B (~ B4), with superimposed chromospheric lines. ΔT is the time in days since fourth contact. The chromospheric material shows different densities (or different temperatures) in different years.

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