



# Probability Analysis of Coincident Blinkers and Explosive Events

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## ABSTRACT

TRADITIONALLY, BLINKERS, BRIGHTENINGS AT NETWORK CELL JUNCTIONS, ARE SEEN WITH SOHO/CDS AND EXPLOSIVE EVENTS OR HIGH VELOCITY EVENTS ARE SEEN IN HIGH RESOLUTION UV SPECTRA FROM HRTS AND SOHO/SUMER. RECENTLY STUDIES HAVE BEEN CARRIED OUT COMPARING THE FREQUENCY OF CO-INCIDENCE OF BLINKER AND EXPLOSIVE EVENTS USING SOHO/CDS AND SOHO/SUMER DATA. WE PRESENT A PROBABILITY MODEL THAT HYPOTHESIZES THAT BLINKERS AND EXPLOSIVE EVENTS ARE RANDOM AND NOT CONNECTED IN ANY WAY. THE CO-INCIDENT BLINKER AND EXPLOSIVE EVENT RESULTS OF BEWSHER ET AL. (2004) SUGGEST THAT THE HYPOTHESIS CAN NOT BE REJECTED BUT THE RESULTS OF BRKOVIC & PETER (2004) ARE INCONCLUSIVE.

## INTRODUCTION

**Blinkers** are small-scale intensity enhancements that have been observed using SOHO/CDS (Harrison et al., 1995). Recently, both CDS and SUMER data have been used to determine the dynamics of blinkers. Blinkers are predominantly more red-shifted than the whole of the transition region (Bewsher et al., (2003), Madjarska & Doyle (2003)). Some debate exists over the line width of blinkers, however. Bewsher et al., (2003) used CDS data to show that the line width of blinkers was predominantly larger than the whole of the transition region, but using SUMER data, Peter & Brkovic (2003) found that the line width of blinkers decreased over the blinker's lifetime, reaching a minimum at the peak of the blinker's intensity. A number of mechanisms have been suggested to explain blinkers but none of the suggested mechanisms have been verified.

**Explosive events** are characterised by strong non-Gaussian enhancements in the wings of their line profiles resulting from a high velocity component ranging from 50 to 200 km s. They were first observed using HRTS, but are commonly identified now with SUMER (Wilhelm et al., 1995). Explosive events occasionally have intensity enhancements associated with them. Dere et al. (1991) and Dere (1994) associated explosive events with magnetic reconnection that occurred during the cancellation of magnetic flux and Innes et al. (1997) presented a model of the magnetic reconnection configuration required for an explosive event to occur.

Speculation that blinkers and explosive events are the same phenomena has continued even though much research has been carried out on the individual phenomena. Most authors (Chae et al. (2000), Madjarska & Doyle (2003), Peter & Brkovic (2003), Brkovic & Peter (2004), Bewsher et al. (2004)), however, suggest that the 2 types of phenomena are not connected, but debate still occurs.

## DATA

Recently, two papers have investigated the coincidence of explosive events and blinkers.

**Brkovic & Peter (2004)** analysed 5 SUMER data sets (total duration 18.5 hours) where events in SUMER called blinkers were identified automatically (using method of Brkovic, Solanki & Rüedi, 2001) and explosive events were identified by eye. They found **778** explosive events of which **412** coincided with **342** blinkers. In total they identified **1086** blinkers

**Bewsher et al. (2004)** analysed 3.5 hours of co-aligned CDS and SUMER data and automatically identified both blinkers (using BLIP, Bewsher, Parnell and Harrison 2002) and explosive events in both data sets. They found **1** example of a coincident explosive event and blinker, **10** examples of lone blinkers and **7** examples of lone explosive events.

## PROBABILITY MODEL

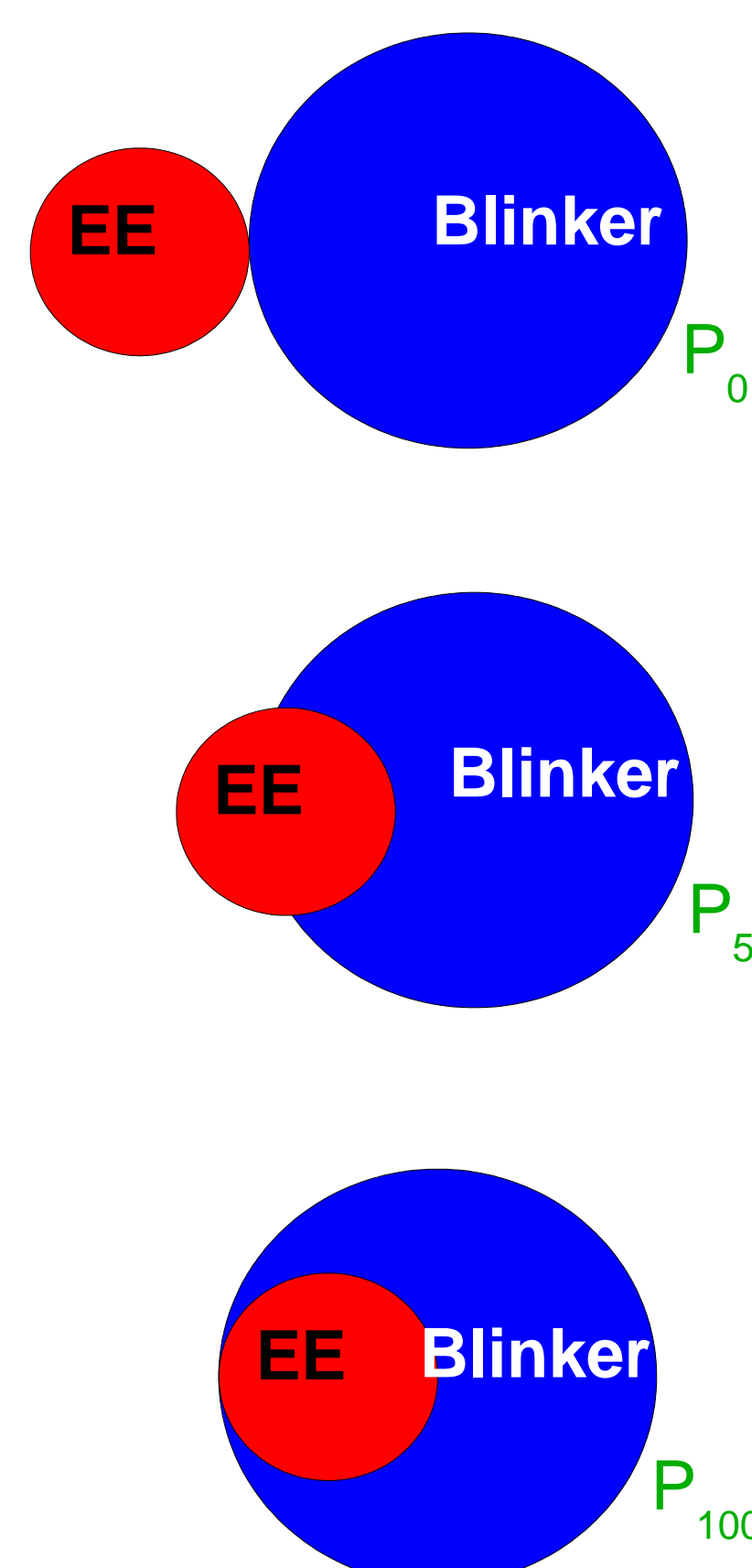
Given a data volume (area x time), within which there is a known blinker volume, the probability that an explosive event occurring in the data volume coincides with the blinker volume can be represented as a Bernoulli trial with probability **P**. Multiple explosive events will have a binomial distribution with parameters **n<sub>e</sub> = number of explosive events** and **P**.

The mean number of coincidences is  $\mu = n_e P$

and the standard deviation is  $\sigma = \sqrt{n_e P(1-P)}$

We define three probabilities; **P<sub>100</sub>** is the probability that an explosive event is completely enclosed by a blinker; **P<sub>50</sub>** is the probability that at least 50% of an explosive event overlaps a blinker; and **P<sub>0</sub>** is the probability that (0,100)% of an explosive event overlaps a blinker.

Assuming (i) that blinkers and explosive events are basically circular and (ii) a percentage volume (area x time) containing blinkers, then we can calculate **P<sub>100</sub>**, **P<sub>50</sub>** and **P<sub>0</sub>**.



## RESULTS

Bewsher et al (2004) give the percentage volume of the blinkers they identify in their CDS data as 6.7%. This is comparable to the 4% and 5% given by Bewsher, Parnell & Harrison (2002) and Brkovic, Solanki & Rüedi (2001) and makes no difference to our probability results. The table below shows the number of explosive events identified in the analysis of Bewsher et al. (2004) (BIPB) and Brkovic & Peter (2004) (BP 6.7), the number of coincident explosive events and blinkers, and the mean and standard deviation for the 3 different values of P.

	BIPB			BP 6.7			BP 50		
	P <sub>0</sub>	P <sub>50</sub>	P <sub>100</sub>	P <sub>0</sub>	P <sub>50</sub>	P <sub>100</sub>	P <sub>0</sub>	P <sub>50</sub>	P <sub>100</sub>
No. of EE's observed (n <sub>e</sub> )	8	8	8	778	778	778	778	778	778
No. of coincident EE's with blinkers	1	1	1	412	412	412	412	412	412
Probability (P)	0.094	0.067	0.040	0.094	0.067	0.040	0.990	0.500	0.045
Mean (μ)	0.75	0.54	0.32	73	52	31	770	389	35
Standard deviation (σ)	0.82	0.71	0.56	8	7	5	3	14	6
Hypothesis (R/N)	N	N	N	R	R	R	R	N	R

In all cases, the results of Brkovic & Peter (2004) using the 6.7% volume coverage, lead us to reject our hypothesis that blinkers and explosive events are random and not connected in anyway. Opposite to this, the data presented in Bewsher et al. (2004) suggest that we can NOT reject our hypothesis.

But, Brkovic & Peter (2004) identified their blinkers in SUMER data and so a 6.7% volume coverage maybe unsuitable for the events that they identified. As Brkovic & Peter (2004) do not give the properties of the events that they identified, we use the SUMER blinker area of 2 Mm<sup>2</sup> and lifetime of 16 minutes given in Bewsher et al. (2004) and the quantity of blinkers (1086) identified by Brkovic & Peter (2004) to calculate a more suitable percentage volume of 50%. This is 10 times greater than the previous percentage volumes calculated by Brkovic, Solanki & Rüedi (2001) and Bewsher, Parnell & Harrison (2002)!! The table above also shows the probability analysis using the higher percentage volume implied by Brkovic & Peter (2004) (BP 50).

There is a large spectrum of probabilities and mean number of coincidences depending on the percentage overlap that are calculated from the results of Brkovic & Peter (2004). However, there is a probability range in the middle of this spectrum where we can not reject our hypothesis.

## CONCLUSIONS

The results of Bewsher et al. (2004) support the hypothesis that blinkers and explosive events are random and not connected in anyway. However, using the percentage volume of blinkers stated by Bewsher et al. (2004), the results of Brkovic & Peter (2004) lead us to reject the hypothesis. Using a higher percentage volume determined from SUMER blinker properties given in Bewsher et al. (2004) and the number of blinkers identified by Brkovic & Peter (2004), there is one case where the hypothesis is supported. Namely, where at least 50% of the blinker and explosive event coincide. The results of Brkovic & Peter (2004) produce inconclusive results.

So are blinkers and explosive events the same phenomena? Our probability analysis suggests that it is unlikely. Further analysis of both blinkers and explosive events in both CDS and SUMER is necessary before the true relationship can be established.

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