Effect of Limited Stirring on the Belousov Zhabotinsky Reaction

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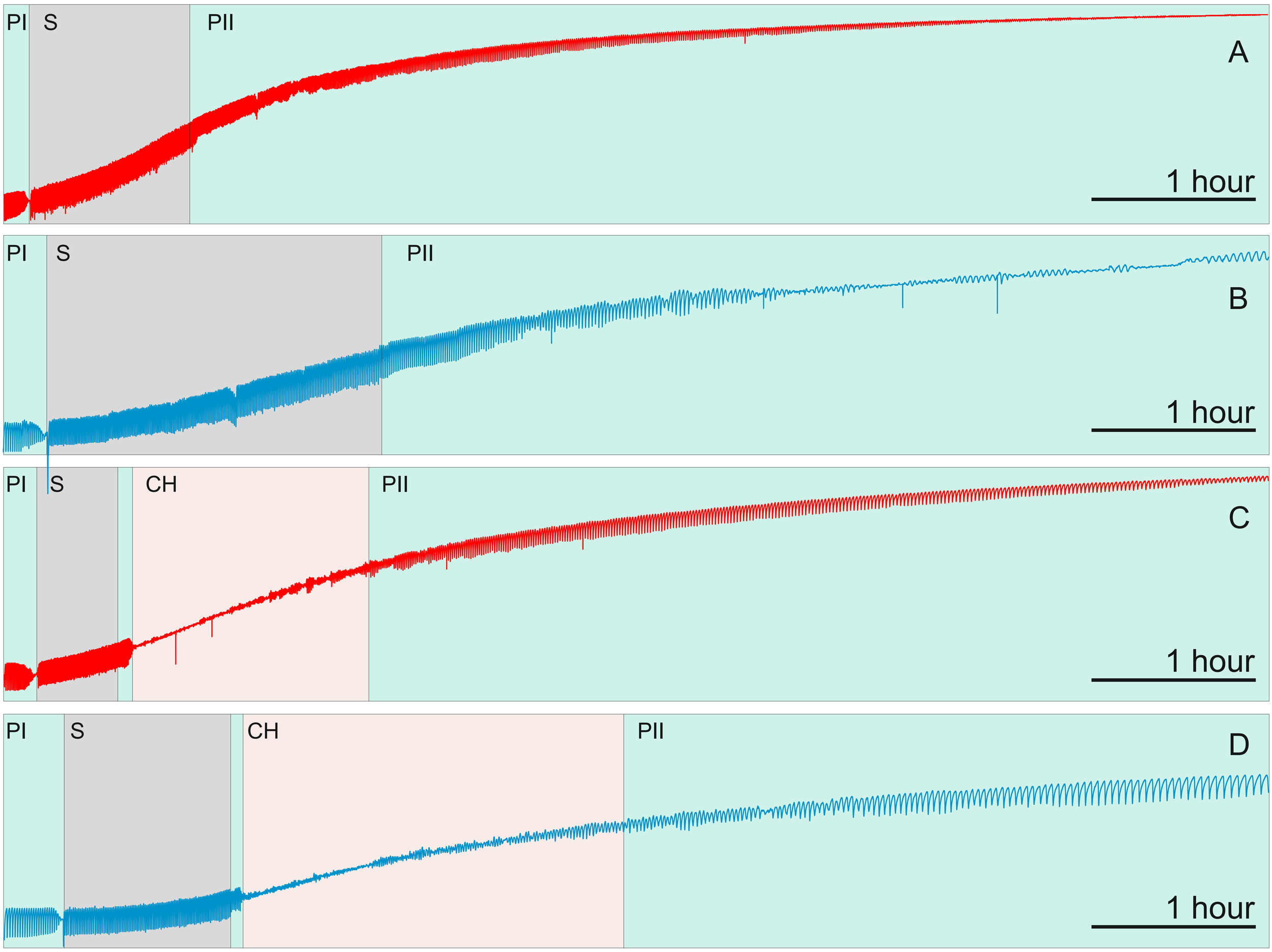

Figure 1: Effect of temperature on the periodic color change. In general there exist four distinct regions (phases): the first periodic phase (PI), the stirring phase (S) and a short periodic phase right after (PS), the aperiodic (chaotic) phase (CH) and the second periodic phase (PII)**. A and B:** Similar behavior at different temperatures and different stirring times; B: stirring time 120 min at 21°C (blue)., A: stirring time 60 min at 30°C (red). **C and D:** Similar behavior at different temperatures and different stirring times; D**:** stirring time 60 min at 21°C (blue)., C**:** stirring time 30 min at 30°C (red).

Abstract. ***The effect of a limited stirring phase on the general behavior of the periodic color change in a closed Belousov Zhabotinsky (BZ) reaction was investigated systematically. In general the color change in an unstirred and closed BZ reaction system goes through different stages (phases) before it 'dies out' after approx. 10 hours. After a short (approx. 20 min) periodic (initial) phase it evolves into an aperiodic (chaotic) phase which last for approx. 1 hour. This phase is followed by a second periodic phase which last up to 8 hours. A limited stirring phase can result in a shortening or the complete disappearance of the aperiodic phase which is present in the non-stirred case. Therefore we suppose that the stirring time plays the role of a bifurcation parameter.***

Experimental Facts

In this work we report our investigation on the effect of a limited stirring phase on the behavior of the BZ reaction and especially the effect of temperature on it. The effects of stirring can be seen easily from the fact that if the BZ reaction is stirred at a 'high' rate, the color oscillations stop immediately, and when the stirring is stopped, almost immediately the oscillations restart. If the BZ reaction is stirred at a 'low' rate, the color oscillations sustain and moreover the time period of the oscillations becomes regular. If the stirring is done for a limited time the general behavior changes. A typical time evolution of the periodic color change with a limited stirring phase at different temperatures is shown in figure 1.

If the reaction is carried out at 'low' temperature (i.e. 21°C) we get a similar effect as when we stir the system for 30 min at 'high' temperature (i.e. 30°C) (fig. 1 A and B). Furthermore we can see that the slope of the moving average of the transmittance is bigger at the beginning of the reaction at 'high' temperature then at 'low' temperature (fig. 2). In addition the behavior of the system after stirring is more 'complex' if the temperature is lower.

Discussion

We show here that a limited stirring phase changes the general behavior of the time evolution of the BZ reaction. In addition we show that this change is depending on the temperature at which the reaction takes place. If the stirring time is only 30 minutes (at 'high' temperature or 60 min at 'low' temperature) the chaotic phase is still present, but compared to the non-stirred case it is shorter; if the stirring phase is 60 minutes (at 'high' temperature or 120 min at 'low' temperature) the phase is not present anymore. In that sense the stirring time plays the role of a 'Bifurcation parameter' (see difference between fig. 1 A, B and C, D).

In general the effect of stirring can be influenced by changing the temperature: at 'low' temperature the system behaves similar as at 'high' temperature if the stirring time is doubled.

Acknowledgments

Experiments were carried out together with Florian Wimmer (for details about the material and method see [1]). Intensive and fruitful discussions with Christian Wodlei, Florian Wimmer, Gabor Lütge and Oliver Pirker are gratefully acknowledged. We thank Sampurna Chaterjee (Max Planck Institute of Neurological Research, Cologne, Germany) for the English language support and also for productive discussions.

[1] **F. Wodlei, M. R. Hristea**: *Effect of Limited Stirring on the Belousov Zhabotinsky Reaction*. CSS Archive, *to appear* (or *http://www.ilsr.at/material_methods.pdf*)

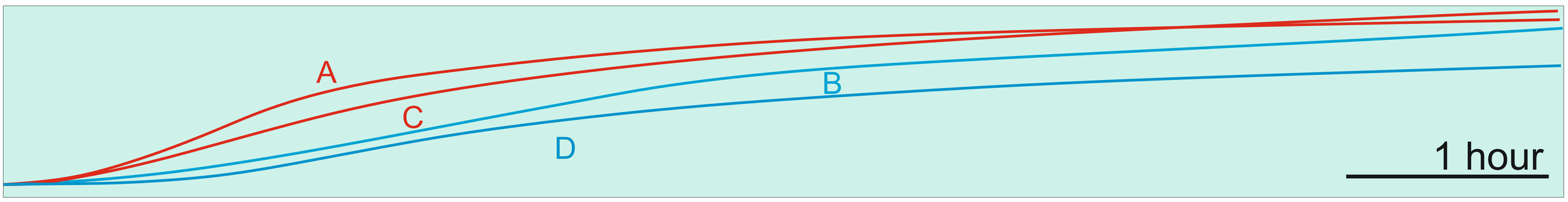

Figure 2: Evolution of the moving average of the transmittance (taken from the measurements of fig. 1). Color code as in fig. 1: A and C were recorded at 30°C (red), B and D at 21°C (blue).