Since the authors did not give any technical details about their calculation, our explanation is not more than a guess; we may be totally wrong.

There are two questions to answer:

1. How could the estimated reactivity be so close to the true value?

2. Why does the minimal value of the score statistics differ seriously from the theoretically prescribed one?

Guess 1: The processed time series was very short ($N = 50$); thus, no serious divergence was able to develop during this time (see Fig. 1). In addition, the score statistic is constructed using the *square* of the innovation; thus, *every* divergence does *increase* the score statistic. Therefore, the smaller the divergence is, the smaller the score statistic is. The amount of the divergence depends on the goodness of the approximation. As a consequence, the better the approximation is, the smaller the score statistic is.

Guess 2: It has been mentioned that $\mathcal{L}(N)$ could take such a value, which is far from its expected value, but this event has a very low probability. Therefore, in such a case, the whole calculation should be repeated again to check the reliability of the estimation. Reference 1 has not mentioned it. Finally, if the authors applied a noise-corrupted dynamic model with the score statistics given by Eq. (4), the whole problem disappears. In this case, Ref. 1 has only forgotten to mention this fact.

We pointed out that the application of the Magill-Bogler procedure in Ref. 1 is *improper* in the sense that the unknown parameter appears in the state transition matrix Φ instead of the control term. This invalid interpretation of the Magill-Bogler method could also be responsible for the whole anomalous effect. It would deserve a detailed analysis to see how the Magill-Bogler technique has to be modified to be able to handle unknown parameters in the state transition matrix, too.

Inspired by D'Attellis and Cortina's idea, another procedure is developed to estimate unknown reactivities.[8,9] Supposing small changes in the reactivity, the effect can be described by the appearance of an extra input term in the point kinetic equations. The unknown reactivity shift becomes an unknown control parameter suitable for the "bank of Kalman filters" procedure.

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REFERENCES

1. C. E. D'ATTELLIS and E. CORTINA, "Simultaneous Estimation of Neutron Density and Reactivity in a Nuclear Reactor Using a Bank of Kalman Filters," *Nucl. Sci. Eng.*, **105**, 297 (1990).

2. A. H. JAZWINSKI, *Stochastic Processes and Filtering Theory*, Academic Press, New York (1970).

3. A. P. SAGE and J. L. MELSA, *Estimation Theory with Application to Communication and Control*, McGraw-Hill Book Company, New York (1971).

4. F. T. SCHLEE, C. J. STANDISH, and N. F. TODA, "Divergence in the Kalman Filter," *AIAA J.*, **5**, 1114 (1967).

5. D. T. MAGILL, "Optimal Adaptive Estimation of Sampled Stochastic Processes," *IEEE Trans. Aut. Control*, **AC-10**, 434 (1965).

6. P. L. BOGLER, "Tracking a Maneuvering Target Using Input Estimation," *IEEE Trans. Aerospace Elec. Systems*, **AES-23**, 298 (1987).

7. A. RÁCZ, "Stochastic Control Rod Calibration," *Ann. Nucl. Energy*, **18**, 585 (1991).

8. A. RÁCZ, "Estimation of Quasi-Critical Reactivity," KFKI-1992-9/G, Central Research Institute for Physics, Budapest, Hungary (1992).

9. A. RÁCZ, "On the Estimation of a Small Reactivity Change in Critical Reactors by Kalman Filtering Technique," *Ann. Nucl. Energy* (in press).

Reply to "On 'Simultaneous Estimation of Neutron Density and Reactivity in a Nuclear Reactor Using a Bank of Kalman Filters'"

1. The efficiency of the proposed method was checked in a simulator that matches the reactor behavior. The robustness analysis was not within the scope of our technical note.

2. $Q_k \to 0$ is a sufficient condition for $K_k \to 0$, but it is not necessary. It is very easy to construct simple examples without a dynamic noise term that verifies $K_k \to 0$ for all $P(0)$.

3. The aim of our method is to obtain a good estimation in a short time interval ($N = 50$ in the example). If the estimation time were longer, the estimation itself would not be useful. Divergencies could appear only in a long-duration Kalman filter operation.

4. Magill proposed a method for estimating a stochastic process with certain unknown parameters. According to Magill's method, the most likely filter is the filter that maximizes the (maximum *a posteriori*) probability $p(\alpha | z_k, z_{k-1}, \ldots, z_0)$ conditioned to measurement data. This is equivalent to selecting from the L hypothesized filters the filter that minimizes a sum of weighted innovations. Bogler estimates the acceleration of a maneuvering target, and the acceleration is the control variable in his model. But the important fact from Magill's analysis is the possibility of making estimations based on calculations involving the innovations. This general principle can be applied to different problems, even when the unknown parameters appear in the state transition matrix. We have successfully used this method in other fields such as acoustic emission signal analysis[1] and failure detection in a heat exchanger.[2]

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REFERENCES

1. C. E. D'ATTELLIS, L. V. PÉREZ, D. RUBIO, and J. E. RUZZANTE, "Parameter Estimation in Acoustic Emission Signals," presented at 13th World Conf. Nondestructive Testing, San Pablo, Brazil, 1992.

2. C. E. D'ATTELLIS, D. RUBIO, L. V. PÉREZ, and P. BRUDNY, "Detección de fallas en plantas en funcionamiento: aplicación a un intercambiador de calor," *Proc. RPIC '91*, Buenos Aires, Argentina, 1991.