

Feedback in Optics

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The use of feedback in optics has many varied facets. Applications range from the solution of partial differential equations to those of binary logic elements. The papers in this issue present a representative coverage of the topic.

An extremely simple approach is a closed circuit TV system with the camera looking at the monitor. Three types of operation can be identified. The first is optical image processing where feedback gives a wider range of transfer functions. The second is the solution of spatial-temporal partial differential or integral equations where the kernel is determined by the feedback system, and the third is the generation of bistable or multistable states which can be used for optical computing. These areas are all covered in the paper by Ferrano and Häusler. Similar arrays of bistable states are described in the article by Gerlach et al. where the output from a liquid crystal light valve optical spatial light modulator is fed back to its input.

Another example of the application of feedback to optical systems is given in the hybrid systems described by Smith. In these devices a beam of light shining into a device may come out either bright or dim depending on the state of the device. Hybrid devices are so designated because they use electronics in the feedback loop in addition to the optics. They also usually use an optical resonator which provides additional optical feedback so that it acts like a nonlinear element. The hybrid systems deal with a single beam but can achieve good speed and versatility and have applications for pulse shaping for fiber optical communications and for gates in optical digital computing.

There has been a considerable amount of work on the application of optical feedback to molecular systems in an optical resonator. The result here is also a device with a given input beam

which can have an output beam with one of two stable intensity levels. The feedback is provided by the optical resonator which has the effect of cohering the atoms much as is done in a laser. The paper by Gibbs, McCall, and Venkatesan contains a survey of the work done to date followed by an estimate of the potential capabilities of such a system. The work using semiconductors is exciting because of the potential high speed, low switching energy, and small size. These systems have been studied theoretically and verified experimentally.

The application of feedback to produce bistability in molecular systems has provided a new system amenable to theoretical examination being characterized by the interaction of radiation with a molecular system with phase transitions far from equilibrium. In this context there has been a considerable effort. The paper by Farina, Narducci, Yuan, and Lugiato is the most recent of such studies. The transitions of a molecular system near the transition threshold are examined theoretically. On one hand there could be barrier tunneling to provide false transitions. As a measure of this, one can calculate the probability for false transitions or the mean lifetime in a designated state. These significant calculations are both presented in that paper.

The review paper by Collins & Wasmundt provides a broad-brush survey of all areas. A bit more than average space is devoted to molecular bistability because a model which can be used to picture the physical processes is presented. Also the subject of catastrophe theory useful for visualizing bistable systems is briefly discussed. An extended bibliography is also given.

In general, the application of feedback to optical systems reviewed in the articles in this issue covers a wide range of applications and studies.