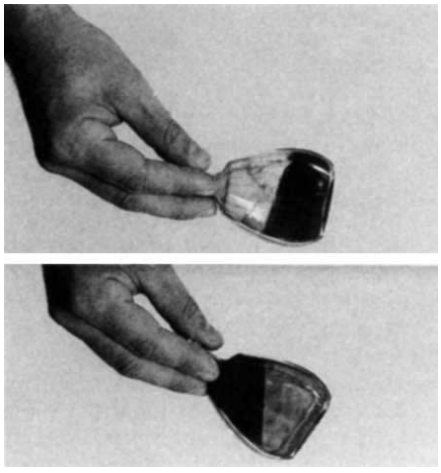
Working bloody miracles

SIR — Among the religious relics from mediaeval times that are today venerated by the Roman Catholic Church are remains of the blood of early saints. Some of these samples become liquefied from their usual clotted state on specific occasions when their containers are handled by religious leaders. A vial of the blood of Saint Januarius (San Gennaro), for example, has been liquefied every few months since 1389 in Naples. The event draws crowds of thousands and a television and media audience of millions. The phenomenon seems genuine, is well documented, and is still regarded as unexplained[1].

We propose that thixotropy may furnish an explanation. Thixotropy denotes the property of certain gels to liquefy when stirred or vibrated, and to solidify



again when left to stand. Shaking or often slight mechanical disturbances thus make a thixotropic substance more fluid, even to the extent of changing it from a solid to a liquid[2].

In the typical blood-liquefaction ceremony, performed at different room temperatures, the act of checking whether liquefaction has occurred comprises repeatedly inverting the glass-walled portable relic case: a shear stress is thereby applied at this critical moment. Thus a successful performance of the rite does not involve any conscious cheating. Indeed, inadvertent liquefaction events have been observed many times over the centuries during handling for repairs to the case that contains the sealed vial[3].

In support of our hypothesis of thixotropy, we have been able to reproduce liquefaction of samples resembling the blood relics that we have prepared using substances available in the fourteenth century. To a solution of 25 g $FeCl_3.6H_2O$ in 100 ml of water we slowly added 10 g $CaCO_3$, and dialysed this solution for 4 days against distilled water from a Spectra/por tubing (parchment or animal gut work just as well; a simple procedure[4] even allows us to avoid this dialysis step). The resulting solution was allowed to evaporate from a crystallization disk to a volume of 100 ml (containing about 7.5% FeO(OH)). Addition of 1.7 g NaCl yielded a dark brownish, thixotropic sol which set in about 1 hour to a gel. The gel could be easily liquefied by gentle shaking, and the liquefaction–solidification cycle was highly repeatable[5] (see figure).

The thixotropic property of this mixture was tested[6] in a CS-Bohlin rheometer (C14 coaxial cylinders system; stress sweep test, 1 Hz, 25 °C). After a 50-min setting time inside the sample cell, a shear stress (0.15–5 Pa) was applied; from the maximum in the G″ (loss modulus) curve and the inflection point of the δ (log phase) curve, we deduce a yield stress of about 4.5 Pa, corresponding to an elastic–viscous (gel–sol) transition. The same test performed after a 50-min setting time, followed by a shear stress of 5 Pa for 30 s, showed no evidence for a transition.

After making fine adjustments by adding water or NaCl, we obtained the best visual match to the contents of the Naples vial using 30 ml of this mixture in a 50-ml, round and flattened bottle. We note that ferric chloride can be found in the form of the mineral molysite on active volcanoes such as Vesuvius.

We are attempting to prepare thixotropic mixtures from other substances. Among those that have met with some success are clays (56 g finely ground bentonite[7] stirred in 100 ml water works well), beeswax in alcohol, and inorganic pigments in linseed or castor oil.

The chemical nature of the Naples relic can be established only by opening the vial, but a complete analysis is forbidden by the Catholic Church. Our replication of the phenomenon seems to render this sacrifice unnecessary.

LUIGI GARLASCHELLI
Department of Organic Chemistry, University of Pavia, Via Taramelli, 10 – 27100 Pavia, Italy
FRANCO RAMACCINI
Viale Papiniano, 44 – 20123 Milan, Italy
SERGIO DELLA SALA
Department of Neurology, S. Paolo Hospital, Via Di Rudiní, 8 – 20142 Milan, Italy

1. *Encyclopaedia Britannica* 15th Edn, Vol. 6, 495 (1985).
2. Mardles, E. W. J. *Nature* **159**, 70–71 (1947).
3. Alfano, G. B. & Amitrano, A. *Il miracolo di S. Gennaro* (Scarpati, Napoli, 1950).
4. Guthknecht, R. *Bull. Soc. Chim. Fr.* **13**, 55–60 (1946).
5. Schalek, E. & Szegvary, A. *Kolloid Zeitschr.* **32**, 318–319 (1923).
6. Eisenberg, A. *et al. A. Rev. Mater. Sci.* **6**, 335–359 (1976).
7. Reyes, E. thesis, Univ. Granada (1977).

Quantum eraser

SIR – Scully *et al.*[1] propose several two-source interference experiments. In one, the interference effect is wiped out by measurements that are so 'delicate' as not to disturb the system, although they yield information about the source of the detected particle. In another experiment dealing with the 'quantum eraser' concept[2–4], they point out that the lost interference effect can in principle be recovered by measurements that effectively erase the information about the source of the detected particle. But, in a way, both these effects have already been observed (refs 3–5; P. G. Kwiat *et al.*, in preparation), although not described in the language used by Scully *et al.*[1], and they involve the process of parametric down-conversion in a nonlinear crystal, rather than the micromaser, the principle is similar.

In the down-conversion process a beam of light of frequency ω_0 (the pump), usually from a laser, interacts with a medium having a χ^2 non-linearity in such a way that incident pump photons split into two simultaneous lower frequency photons, historically known as signal and idler, whose frequencies add up to ω_0. The two photons usually emerge in different directions simultaneously and their state is an entangled quantum state.

The quantum eraser concept discussed by Scully *et al.*[1] is realized by Ou *et al.*[3] in a different way (Fig. 1). NL1 and NL2 are two similar nonlinear crystals optically pumped by strong, mutually coherent light beams V_1 and V_2. Signal (s) and

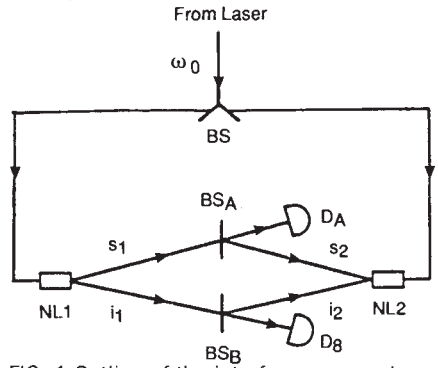


FIG. 1 Outline of the interference experiment with two down-converters[3].

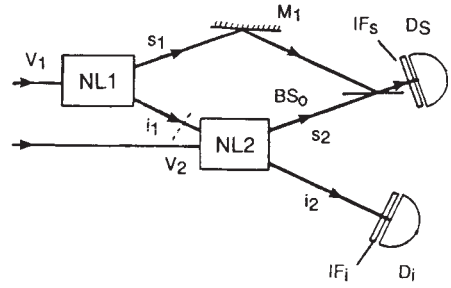


FIG. 2 Outline of the one-photon (second-order) interference experiment (from ref. 4).

idler (i) photons emerge from both crystals. The signal photons s_1,s_2 are mixed by beam splitter BS_A and the mixed beam falls on detector D_A. Similarly, idler photons i_1,i_2 are mixed by beam splitter BS_B and detected by D_B. In quantum mechanics interference is the manifestation of the addition of probability amplitudes for several different, indistinguishable, possible paths. As the alternative paths from NL1 to BS_A, BS_B and from NL2 to BS_A, BS_B are completely indistinguishable, the corresponding probability amplitudes add. Interference should therefore show up in the joint detection probability, or the rate of coincidence detection, by D_A and D_B as a function of path difference. This was indeed observed in the experiment[3].

The interference can, however, be destroyed by a 'delicate' change in the experiment, for example the removal of beam splitter BS_B, which would at first sight appear to have no effect on the signal photons. But because signal and idler photons are produced simultaneously, once BS_B is removed it becomes possible to tell from the output of D_B whether the corresponding signal photon detected by D_A comes from NL1 or NL2. Restoring BS_B and mixing the idlers restores the interference, but only in the coincidence counting rate. In the language of Scully *et al.*[1], the insertion of BS_B, mixing of the idlers and subsequent detection by D_B 'erases' the path information, restoring the interference.

It is possible to change the configuration of Fig. 1 in such a way that mixing the idlers restores the interference without the need for coincidence detection. An example of such an experiment is shown in Fig. 2 (refs 4,5). Here, the two nonlinear crystals NL1 and NL2 are arranged so that two idlers i_1 and i_2 are aligned in direction and idler i_1 passes from NL1 to NL2. It is now impossible in principle to tell whether the photon detected by D_S comes from NL1 or NL2, so long as the i_1 trajectory from NL1 to NL2 is not interrupted. The alignment of i_1,i_2 therefore serves as the 'quantum eraser' in the experiment. However, as soon as the NL1 to NL2 coupling is broken, say by deflection of the i_1 beam, or by insertion of a stop or even a sufficient time delay, it becomes possible to tell from a measurement made with an auxiliary (very efficient) detector D_i whether the photon registered by D_S comes from NL1 or NL2. Evidently, it comes from NL2 if D_S and D_i register counts simultaneously, and it comes from NL1 otherwise. The interference effect should therefore disappear when the NL1 to NL2 path is blocked. This too has been observed[4,5].

In this case i_1 'induces coherence' between the signals without inducing emission, even though opening or closing the path NL1 to NL2 does not physically perturb the s_1,s_2 beams. Thus the state vector reflects not only what is known about the photon, but also what is knowable in principle. The 'auxiliary' measurements to identify the source or the path of the detected photon need not be carried out; it is sufficient for them to be possible, in principle, for the interference to be destroyed.

A. G. ZAJONC*
L. J. WANG
X. Y. ZOU
L. MANDEL

Department of Physics and Astronomy, University of Rochester, Rochester, New York 14627, USA

* Permanent address: Department of Physics, Amherst College, Amhurst, Massachusetts 01002, USA.

1. Scully, M. O., Englert B.-G. & Walther H. *Nature* **351**, 111–116 (1991).
2. Scully, M. O. & Druhl, K. *Phys. Rev.* **A25**, 2208 (1982).
3. Ou, Z. Y. *et al. Phys. Rev.* **A41**, 566 (1990).
4. Zou, X. Y., Wang, L. J. & Mandel, L. *Phys. Rev. Lett.* **67**, 318–321 (1991).
5. Wang, L. J., Zou, X. Y. & Mandel L. *Phys. Rev. A* (in the press).

Actin in ribbons

SIR — We have proposed that actin filaments can be transformed by a twist and a stretch into 'ribbons', which we believe might be important for understanding the mechanism of force generation[1]. Our conjecture has been dismissed[2] on the grounds that it is inconsistent with the 'known' atomic structure of the thin filament[3]. This criticism is largely based on our use of the terms 'small' and 'large' to designate the axial and distal domains of the actin monomer as it packs into the ribbon. Notwithstanding the obvious confusion caused by the near identical size of the two domains, our analysis rested on the consistency of the radial position of the penultimate cysteine residue with fluorescence transfer data. Recent gold-labelling experiments[4] establish the similarity of actin-monomer orientation in the ribbon[1] and helix[2] states.

In agreement with DeRosier[5], we take issue with the claim that the structure of F-actin has been established at high resolution as the 'atomic' model is restrained by diffraction data limited to at best 8.4 Å in the meridional direction and even less radially. Furthermore, the axial contact (the 'finger') is produced by *ad hoc* intervention without any supporting high-resolution data. We do not understand Holmes and Kabsch's insubstantiated contention[2] that a 30° rotation of the actin monomer would give a model consistent with F-actin but with contacts different from those in the profilin:actin crystals, as we have not presented a high-resolution analysis. The crucial issue remains whether the genetic helix contacts are strong, as we think the balance of experimental data supports, or rather tenuous, as seen in the Holmes and Kabsch model.

CLARENCE SCHUTT
UNO LINDBERG
JAMES MYSLIK

Department of Chemistry, Princeton University, Princeton, New Jersey 08544, USA

1. Schutt, C. E., Lindberg, U., Myslik, J. & Strauss, N. *J. molec. Biol.* **209**, 735–746 (1989).
2. Holmes, K. C. & Kabsch, W. *Curr. Op. Struct. Biol.* **1**, 270–280 (1991).
3. Holmes, K. C., Popp, D., Gebhard, W. H. & Kabsch, W. *Nature* **347**, 44–49 (1990).
4. Milligan, R. A., Whittaker, M. & Safer, D. *Nature* **348**, 217–221 (1990).
5. DeRosier, D. *Nature* **347**, 21–22 (1990).

Where next for canine virus?

SIR — Canine distemper has been recognized as a lethal infectious disease of the domestic dog for more than 200 years. Later observations have extended the known host range to include the coyote, wolf, fox, ferret, mink, skunk, raccoon, badger, panda and macaca, to name but a few. In the past 3 years, studies of mass mortalities in seals, porpoises and dolphins have revealed canine distemper or canine distemper-like infection, hitherto unknown in such marine mammals. In seals two agents are involved: canine distemper virus (CDV) and 'phocid' distemper virus, the latter perhaps a mutant of the classical dog agent.

We have investigated an episode of a fatal central nervous system disease in javelinas (collared peccaries) which live as feral animals in Arizona[1]. Javelinas resemble small pigs but are not directly related to pigs. We discovered that the deaths are caused by CDV encephalitis; other, healthy animals showed serological evidence of subclinical infection. By monoclonal antibody studies we found that the isolated virus is classical CDV, and not the mutant form. The javelina is also susceptible to bovine Rinderpest virus[2], a morbillivirus closely related to CDV and human measles.

Clearly, CDV is a pervasive pathogen that can cause infection and disease in an unusually wide spectrum of domestic, wild and marine animals. It has recently been incriminated in some cases of Paget's disease of bone in humans[3]. Where will it turn up next?

M. J. G. APPEL*

James A. Baker Institute for Animal Health, NYS College of Veterinary Medicine, Cornell University, Ithaca, New York 14853, USA

* Other signatories: B. A. Summers, S. Pearce-Kelling, C. Reggiardo, C. J. Maré, T. H. Noon, R. E. Reed, J. N. Shively and C. Örvell.

1. Appel, M. *et al. Archs Virol.* **119**, 147–152 (1991).
2. Dardiri, A. H., Yedloutschnig, R. J. & Taylor, W. D. *Proc. 73rd Annual Meeting US Am. Hlth Ass.* 437–452 (1969).
3. Gordon, M. T., Anderson, D. C. & Sharpe, P. T. *Bone* **12**, 195–201 (1991).