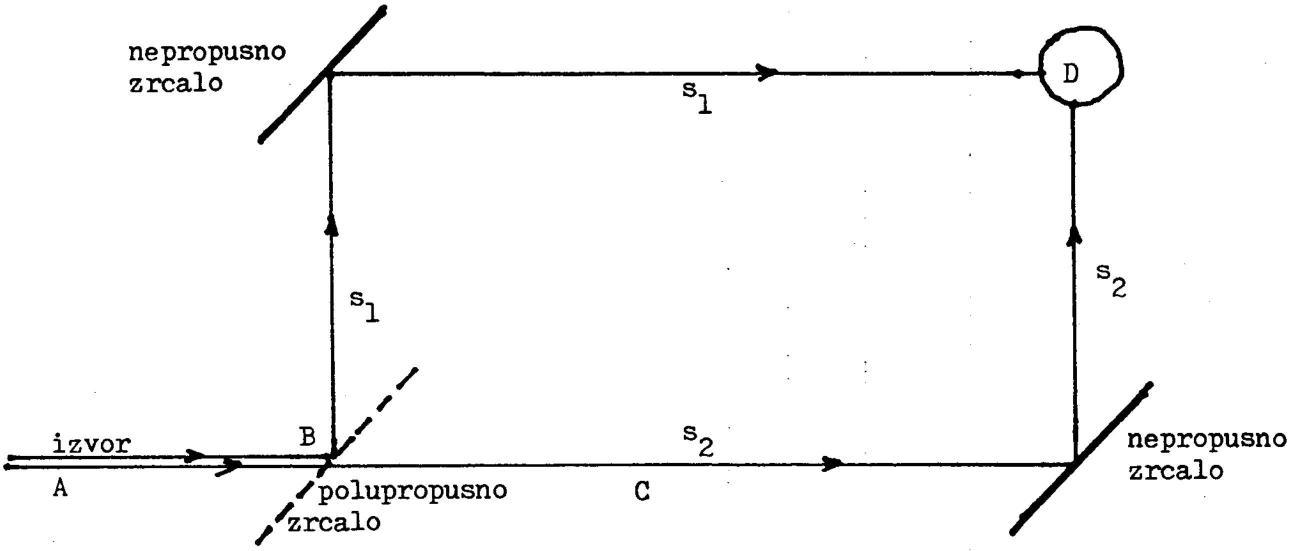
Posljednji zahtjev predstavlja spoj statističke i individualne manifestacije kvantnog objekta i ne može se opravdati isključivo individualnim svojstvima njegovim. Preciznije, za individualna mjerenja premise nikad nisu netrivijalno ispunjene i svode se na slijedeću mogućnost: $C \vee \neg C \dashv\vdash \Box\Diamond A \dashv\vdash \Box\Diamond B$. Samo individualno mjerenje svodi se na slijedeće mogućnosti: $C \vee \neg C \dashv\vdash \Box\Diamond A \dashv\vdash \Box\Diamond B$, $C \wedge \neg C \dashv\vdash \Box\Diamond A \dashv\vdash \Box\Diamond B$, $C \vee \neg C \dashv\vdash \Box\Diamond A$ & $C \wedge \neg C \dashv\vdash \Box\Diamond B$ i $C \wedge \neg C \dashv\vdash \Box\Diamond A$ & $C \vee \neg C \dashv\vdash \Box\Diamond B$. Drugim riječima mi zahtjevom 7 proširujemo formalizam zasnovan na logici individualnog mjerenja do formalizma koji će nam omogućiti istovremeno tretiranje statističke manifestacije takvog mjerenja. U klasičnoj logici koja odgovara klasičnoj mehanici nema potrebe za adekvatnim postupkom budući statistička svojstva proizlaze iz individualnih. U kvantnoj logici koja odgovara kvantnoj mehanici dedukcija statističkih svojstava iz individualnih nije direktno moguća. Da bismo to projasnili razmotrimo jedan tipično i isključivo kvantni fenomen.

Neka je postavljen fotonski eksperiment, prikazan na slijedećoj slici:



koji rezultira interferencijom u području D, ukoliko nam ostaje nepoznato na koji je način individualni foton dospio u područje D i ukoliko nu na raspolaganju stoje i staza s_1 i staza s_2. Kao što je poznato, eksperimentalne činjenice su slijedeće: Ako nakon prolaska fotona kroz polupropusno zrcalo B, a prije nego što je foton mogao stići u točku C, iznenada ubacimo u točki C detektor na stazu s_2 i ne registriramo ništa onda slijedi da je foton "putovao" stazom s_1 - i, zaista, on biva registriran u području D ali tamo ne producira interferenciju. U kvantnom slučaju, kad se u području D registrira interferencija, moramo zaključiti da ukoliko foton koristi obje staze istovremeno mi ne možemo naći eksperimentalnu proceduru kojom bismo to direktno bilo dokazali bilo opovrgli. Međutim, činjenica da detekcijom "ničega" u točki C destruiramo interferenciju implicira da foton ipak "nekako" koristi i drugu stazu kad pretpostavimo da putuje prvom. (Čuveni von Neumannov projekcioni postulat i tzv. redukcija valnog paketa nam ovdje, naravno, ne mogu poslužiti kao "objašnjenja" - oni su samo nazivi za navedenu osobitost kvantnog objekta.) Ova pretpostavka potkrijepljena je i posljednjim rezultatom Alberta, Aharonova i D'Amatoa[1] koji zaključuju: "Bell je istakao da usprkos argumenta Gleasona i Kochena i Speckera, i bez iznevjeravanja statističkih predviđanja kvantne mehanike, može biti konzistentno pretpostavljeno da nekomutirajuće observable mogu biti simultano određene. Ova razmatranja sugeriraju nešto jače: Usprkos tom argumentu i uz dane statističke predikcije, nekonzistentno je pretpostaviti bilo što drugo".[1] Pretpostavka je također implicitno učinjena i u nekim oblicima kvantne logike kad se pretpostavlja postojanje propozicija čija stanja (mjere vjerojatnosti) poprimajuvrijednosti strogo veće od nule i strogo manje od jedan, izjednačenjem stanjâ s prelaznim vjerojatnostima kao tipično statističkim veličinama.[2]

U našem pristupu zahtjev 7 je u vezi s odvajanjem ortokomplementiranosti od ortogonalnosti. Ortokomplementiranost smatramo specifično individualnim pojmom, dok ortogonalnost definiramo kao djelomično statistički pojam.[3]

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[1] D.Z. Albert, Y. Aharonov & S. D'Amato (1985)

[2] W. Guz (198o); [3] u def 51/I, za razliku od def na str 89.

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ALGEBARSKO-LOGIČKA STRUKTURA KVANTNO-MEHANIČKIH INTERPRETACIJA

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Realistic Interaction-Free Detection of Objects in a Resonator

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We propose a realistic device for detecting objects almost without transferring a single quantum of energy to them. The device can work with an efficiency close to 100% and relies on two detectors counting both presence and absence of the objects. Its possible usage in performing fundamental experiments as well as possible applications are discussed.

1. INTRODUCTION

Quantum interference of individual systems has recently been found capable of detecting objects without transferring energy to them. The effect has been named *interaction-free-detection*[3] and was based on the void detections which destroy path indistinguishability. In 1986 Pavičić$^{(2)}$ formulated this in the following way. "Consider a photon experiment shown in Fig. 1 which results in an interference in the region D provided we do not know whether it arrived at the region by path s_1 or by path s_2. As is

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[3] Niels Bohr would most likely argue against the name in the following way: "It is true that in the measurements under consideration any direct mechanical interaction of the system and the measuring agencies is excluded, but... the procedure of measurements has an essential influence on the conditions on which the very definition of the physical quantities in question rests.... These conditions must be considered as an inherent element of any phenomenon to which the term "[interaction]" can be unambiguously applied."$^{(1)}$ However, the name has been rather unanimously accepted in the quantum parlance and it is likely to stay there.

well known, the experimental facts are: If we, after a photon passed the beam splitter *B* and before it could reach the point *C*, suddenly introduce a detector in the path s_2 in the point *C* and do *not* detect *anything*, then it follows that the photon must have taken the path s_1—and, really, one can detect it in the region *D* but it does *not* produce interference there. Quantum mechanically, if we registered the interference in the region *D*, we could not find an experimental procedure to directly either prove or disprove that the photon uses both paths simultaneously. However, the fact that by detecting *nothing* in point *C* we destroy the interference implies that the photon *somehow* knows of the other path when it takes the first one." (Ref. 2, pp. 31, 32)

The photon's "knowledge" about the other path can be employed to detect an object (at point *C*) without transferring even a single quantum of energy to it. The efficiency of such an application with a symmetrical Mach–Zehnder interferometer (shown in Fig. 1) is ideally only 25% for single detections and 33% in the long run as shown in Elitzur and Vaidman's detailed formulation of the void detections in interference experiments in 1993.(3) They also showed that one could increase the ideal efficiency to 50% if an asymmetrical beam splitter were used. In 1995 Kwiat *et al.*(4) carried out Elitzur and Vaidman's proposal with an asymmetrical beam splitter using photons obtained in a parametric down conversion. In this way an efficiency close to 50% has been achieved for correlated photons. However, the realization was concerned only with the confirmation of the effect and the 50% efficiency referred to the detected photons which supported the confirmation. For, in the experiment it was necessary to select, with irises, a very small fraction of the photons originally produced in downconversion, which resulted in a net detection efficiency of only 2%. The latter efficiency can be significantly improved(5)

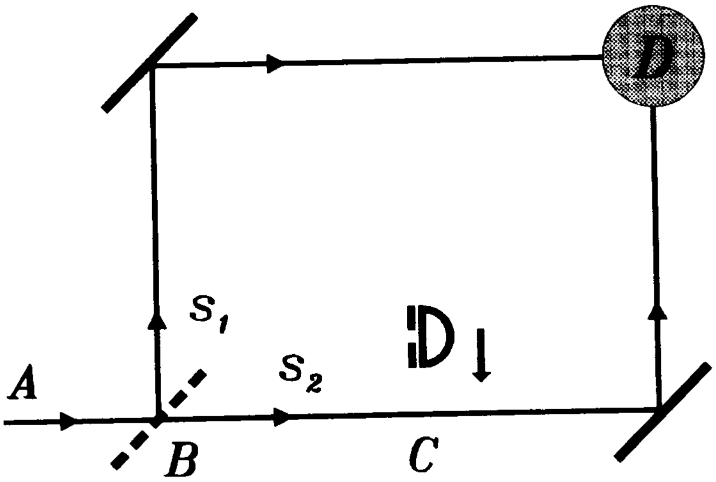

Fig. 1. Figure taken from Pavičić (1986). "By detecting *nothing* in the point *C* we destroy the interference [in the region *D*]." (Ref. 2, p. 31).