adjacent sky background was measured at different position angles with respect to the image.

In summary, following a careful remeasurement of our plates of 3C 345, we reaffirm our published light curve for this quasar. Moreover, in the Yale magnitudes of the reference stars we find no evidence of the hour angle effect claimed by Kinman. It therefore seems doubtful that such an effect should exist only for the quasar. It is unfortunate that Kinman assumed that the Yale photographic magnitudes correspond to his approximate B magnitudes, but not all quasar observations need be carried out on his system. In the absence of additional observational evidence, it is not possible to establish with complete certainty the reality of the "flicker" reported by us, because the chief increase is registered on only one Yale plate. Short period light variations of this amplitude are known to occur in quasars, however. For example, Angione[5] has observed photoelectrically from Cerro Tololo a variation of ~ 0.3 m in B within a 1 h period on the active quasar 3C 454·3. We did not think it unusual that 3C 345 should exhibit similar behaviour at the peak of an optical outburst. Assuming that Kinman's (single) observation of the quasar on the night in question is correct, it would appear that a substantial colour variation took place in 3C 345 on that night. A brightening in the near ultraviolet would register on the Yale plates without necessarily registering at all on Kinman's plate.

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Interstellar Solid Hydrogen: How Much and Where?

FOLLOWING the suggestion that hydrogen may freeze onto grains in some interstellar clouds[1,2], recent calculations have indicated that the grain temperatures will not become low enough[3-5]. The calculations are uncertain, however, because the grain models are in doubt[6] and because little is known about the physical and chemical properties of solid particles and their surfaces in interstellar conditions of temperature, pressure and radiation loading. On the other hand, it has been shown that the properties of galaxies of stars formed from clouds of solid hydrogen grains would possess several features which accord with observation[7-9].

Although most of the theory propounded may apply also to star formation in clouds of molecular hydrogen, it is evidently desirable to look for more direct evidence for or against the existence of clouds of solid hydrogen grains in the galaxy. The question is, then, how much will there be and where should we look for it ?

The freezing of hydrogen onto the grains produces pressure instabilities leading to cloud collapse and star formation[8]. Once hydrogen freezes on to the grains in a cloud, the lifetime of the cloud, which is subjected to an external pressure of uncondensed hydrogen, is rather less than the gravitational collapse time $t = 1/\sqrt{(4\pi G\rho)}$. At interstellar densities $n_H \geq 10^4$ cm^{-3} ($\rho \geq 10^{-20}$ g cm^{-3}), the corresponding cloud lifetimes are $\leq 3 \times 10^5$ yr. If the hydrogen freezes at higher densities, say $n_H = 10^7$ cm^{-3}, the lifetime will be 10^4 yr.

The rate of formation of solid hydrogen will be approximately equal to the rate at which mass condenses to form stars[9], which is 1.3×10^{-17} s^{-1}. The total mass of interstellar hydrogen in the galaxy[10] (assuming that it is mostly HI) is $4 \times 10^9 M_\odot$. The product of the lifetime of a cloud of solid hydrogen grains, the rate of formation per unit mass of HI, and the mass of HI, then gives the total mass of solid hydrogen in the galaxy to be $5 \times 10^5 M_\odot$ if it is formed at a density $n_H = 10^4$ cm^{-3}. Formation at the higher density $n_H = 10^7$ cm^{-3} would reduce this to $2 \times 10^4 M_\odot$.

Star formation seems to occur predominantly in the spiral arms and in aggregates with masses $\sim 10^4 M_\odot$, such as the associations of OB stars. We may therefore expect not more than fifty clouds of solid hydrogen grains with such masses at any one time in the galaxy, and the number may be as low as two. If the larger number were distributed over the galaxy they would be spaced about two kpc apart. The linear diameter with the mass and (lower) density given should be about 5 pc, giving an angular diameter for a nearby cloud at 1 kpc of a third of a degree, and an average angular diameter (at 10 kpc) of 2 arc minutes.

There are at least two methods by which we may search for clouds of solid hydrogen grains.

(*a*) Impure interstellar solid hydrogen may have a typical emission spectrum in the far infrared and microwave region. The spectrum will have to be measured in the laboratory, using hydrogen with a cosmic abundance mixture of impurities and subjected to a radiation loading comparable only with that in interstellar space. This latter requirement is important because of the saturation of energy levels which may occur at higher radiation loadings. Astronomical measurements will require observations above the Earth's atmosphere using microwave and far infrared spectrometers with beamwidths of ≤ 1 arc minute.

(*b*) The freezing of hydrogen onto interstellar grains with an initial grain/atom number ratio $n_g/n_H \approx 10^{-12}$ will increase the grain size from 10^{-5} cm to 10^{-4} cm. Consequently the wavelength of maximum obscuration of starlight will move from 0·2 μm to 2 μm. Near-infrared photometry, to search for regions opaque to background radiation of 2 μm wavelength but transparent at, say, 22 μm, may reveal the presence of clouds of solid hydrogen grains. The obscuration per unit mass at the shorter wavelengths (that is, < 2 μm) will be a hundred times higher after the hydrogen has frozen onto the grains than it was before.

Finally, it is possible that "Bok's globules" and "elephant trunk structures" contain solid hydrogen grains. The bright rims round some of these structures may reveal some effect of evaporation of solid hydrogen before dissociation and ionization.

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