pressure. This is surprising in view of the large temperatures of the shocked materials and the expectation that such phenomena should be nonlinear.

The index-of-refraction measurements of numerous fluids are summarized in fig. 5.2 which follows a similar plot by Kormer with the addition of more recent data by Hardesty [76H1] on nitromethane, by Peterson and Rosenberg [69P2] on gyclerol and ethanol, and by Ahrens and Ruderman [66A3] on hexane and water. For comparison with the data, the Lorenz–Lorentz relations and the Drude relations are shown along with the Gladstone–Dale relation. Also plotted as a dashed line is a temperature-dependent Gladstone–Dale relation which Zel'dovich et al. [61Z1] found to fit the behavior of water to very high compressions. Data on water at compressions of 2 to 20 per cent by Yadav et al. [73Y1] and Zel'dovich et al. [61Z1] are not plotted but they agree with Al'tshuler's values.

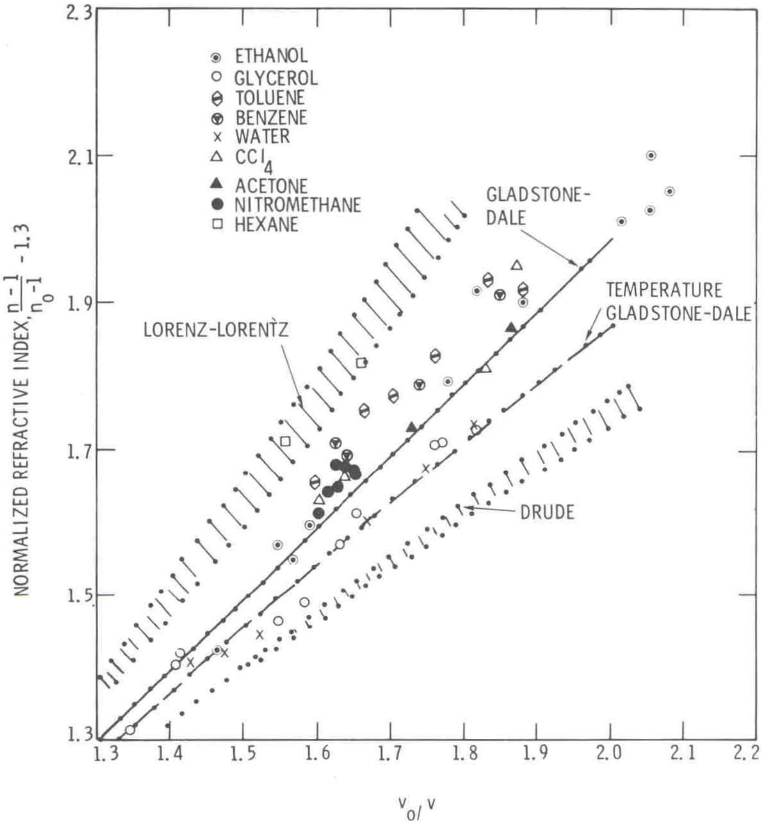

Fig. 5.2. The collected data on index of refraction of shock-loaded fluids give little support to a universal model to describe the effect of compression on refractive index. (After Kormer [68K5].)

The data on hexane seem reasonably well fit by the Lorenz–Lorentz model. Water is well fit by the Gladstone–Dale model at lower compressions [73Y1] and by Zel'dovich's temperature-dependent Gladstone–Dale model at large compressions. Ethanol seems well fit to compressions of 50 per cent by the Gladstone–Dale model. Other fluids do not seem to be particularly well fit by any of the various models, with the Lorenz–Lorentz and Drude models being the least reasonable. The collected data give little support for the use of a particular model to predict the index of refraction of shock-loaded liquids. Nevertheless, the data may be profitably used to construct empirical relationships.

5.2. Shock-induced luminescence

Luminescence of shock-loaded solids has been observed by a number of different investigators and much of that work is summarized by Doran and Linde [66D3]. The observations can be classified into four different categories: (1) thermal radiation due to homogeneous shock heating; (2) thermal radiation from local electrical discharges; (3) triboluminescence due to fracture; and (4) local effects of imperfections, surfaces, or porosity.

Thermal radiation from transparent shock-loaded solids is thoroughly reviewed by Kormer [68K5]. Measurements of thermal radiation from surfaces of opaque solids are reported by Taylor [63T1], King et al. [68K4], and in considerable detail, by Urtiew and Grover [77U1]. Opaque solids whose temperatures must be measured at surfaces are influenced by the effects of shock interactions at surfaces such as have been reported by Asay [76A4]. Urtiew has minimized this problem with the use of transparent windows for which considerable care must be used to secure a proper interface.

Thermal radiation from intense localized electrical discharges accompanying dielectric breakdown (see section 4.6) is prominent in shock-loaded piezoelectrics and has been studied by Neilson et al. [62N2], Brooks [65B3], and Graham and Halpin [68G4].

Triboluminescence is a loosely defined term relating to observation of luminescence when a solid is fractured. It is difficult to find clear-cut examples but the observations of Brooks [65B3] on shock-loaded vitreous silica show a progressive inward moving luminescence from lateral surfaces which is an effect of this nature.

Luminescence has been observed in shock-loaded porous solids [66D3, 66L2, 62B1, 64B3]. Although it is possible that such luminescence might be due to compression of the trapped gases, Blackburn and Seeley [64B3] have shown that luminescence in porous NaCl did not change between samples shocked in air and those shocked in vacuum. On the other hand, Paterson [64P3] found that the luminescence was influenced by trapped gases.

Luminescence has been observed in shock-loaded porous solids [66D3, 66L2, 62B1, 64B3]. has been reported by Coleburn et al. [65C1] who felt the effect was due to an oxide surface layer. Recent observations of the ejection of small material particles, “fluff”, from shock-loaded solids [78A3, 76A4] appear to call for reexamination of such anomalous optical surface effects.

Finally, it should be remarked that localized transient defect production would be expected to cause localized transient thermal effects as would the heterogeneous yielding described in section 3.4.

5.3. Optical absorption

Optical absorption spectra provide a direct probe of electronic properties and measurements under shock loading are of considerable interest. An optical absorption spectrum of ruby between 350 and 700 nm has been measured under shock loading between 15 and 46 GPa by Ahrens and his coworkers [73G1, 79G1]. There is disagreement between the results of the two investigations; the later, more refined, measurement shows a significant nonlinearity in the crystal field parameter