counterrotating [one anticyclonic (high) and one cyclonic (low)] eddies; smaller mesoscale eddies were also present within the domain. In CCS2, leg II, the jet had a more alongshore orientation and its intensity had changed. The changes in jet orientation and intensity were consistent with (i) northwestward displacement of the main cyclonic eddy at a rate of 8 to 12 km per day; (ii) westward displacement of the main anticyclonic eddy at rate of 2 to 4 km per day; and (iii) westward dispersion of the jet, at a rate of 3 to 5 km per day, in the "wake" of the cyclonic eddy. In CCS1, the general pattern (not shown) was a branching jet flowing from northwest to southeast with smaller mesoscale eddies 15 to 30 km in diameter and indications of larger (100 to 200 km) features centered outside the domain. In each quasi-synoptic realization, the CCS included one or more jets (intense current filaments) apparently meandering between counterrotating eddies

We analyzed qualitatively an Advanced Very High-Resolution Radiometer infrared image (from the NOAA-7 satellite) of the SST field (1 August 1982) for an approximately 500-km square domain centered on the study area with only the predominant features schematized (Fig. 1). The general pattern is indicative of cool water upwelled at the coast in the summer season and of relatively warm water advected equatorward by the large-scale California Current. The band of cool water extending offshore from the coast and cutting through the CCS2 domain is a striking feature. This feature is also dominant in the SST map determined from the in situ XBT and CTD data; the SST map, in addition, indicates a sharp surface temperature front (2°C per 20 km; actually, 2°C per 5 km in continuous underway data) on the southern boundary of the cool feature. From the in situ data, the cool feature was about 30 m thick. Comparison of the dynamic topography and the SST maps confirms that the cool feature was coincident with the geostrophic jet, which had presumably advected the feature offshore from the coastal upwelling center off Point Arena. The cool feature entering the domain with the jet also appears in the infrared image. (There is apparently another cool feature in the image, cutting across the cyclonic eddy C. It may be a relic or may be controlled by some other mechanism. Alternatively, since there was a 3-day delay between the capture of the infrared image and the in situ sampling in that area of the domain, this cool feature may have been connected with the other one and, subse-

quent to the imaging, may have been displaced northwest with the cyclonic eddy.) Nearshore, near-surface drifters have documented (6) episodic offshore flowing jets in wind-driven coastal upwelling waters off Point Arena, consistent with the results described here.

In summary, a new conceptual picture of the CCS as a system of filamented jets meandering between synoptic-mesoscale cyclonic and anticyclonic eddies has emerged. The jet and eddy system can change substantially on a weekly time scale. The source of these eddies and their role in the local internal dynamics of the CCS (in either driving or damping the jets) have yet to be determined. This conceptual picture provides a mechanism (entrainment of cool water upwelled nearshore and subsequent offshore advection by jets and eddies) to explain the cool features commonly seen in satellite infrared imagery to extend far offshore from coastal upwelling centers. The advection of cool coastal waters to substantial distances offshore (100 km or more) has significance for the rapid (a few days) offshore transport of nutrients and biota associated with coastal upwelling and of pollutants discharged in the coastal ocean. The jets and eddies also advect warm offshore waters onshore to the coastal ocean. The implications of 22 August 1983; accepted 21 September 1983

these results need to be incorporated in models of coastal ocean circulation, ecosystems dynamics, pollutant dispersal, fisheries, and climate.

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References and Notes

- W. S. Wooster and J. L. Reid, Jr., in *The Sea*, M. N. Hill, Ed. (Wiley, New York, 1963), vol. 2, p. 253;
 B. M. Hickey, *Prog. Oceanogr.* 8, 191 (1976)
- 253; B. M. Hickey, Prog. Oceanogr. 8, 191 (1979).
 The California Cooperative Oceanic Fisheries Investigations Atlas Series.
 J. L. Reid, Jr., and R. A. Schwartzlose, J. Geophys. Res. 67, 2491 (1962); R. L. Bernstein, L. Breaker, R. Whritner, Science 195, 353 (1977); H. P. Freitag and D. Halpern, J. Geophys. Res. 86, 4248 (1981).
 K. Marger, S. A. Bracch, A. B. Dakier, S. M. Brack, A. B. Bakier, S. M. Brack, A. B. Brack, A. B. Bakier, S. M. Bakier,
- 86, 4248 (1981).
 C. N. K. Mooers, S. A. Piascek, A. R. Robinson, Ocean Prediction: The Scientific Basis and the Navy's Needs (Proceedings of the Ocean Predic-tion Workshop, Montercy, Calif., May 1981).
 R. D. Pillsbury, J. Bottero, R. E. Still, G. R. Heath, Oreg. State Univ. Sch. Oceanogr. Rep. OSU-10 (1981); Oreg. State Univ. Sch. Ocean-ogr. Rep. OSU-14 (1982).
 R. E. Davis, "Current-following drifters in CODE" (Scripps Institution of Oceanography SIO Reference No. 83-4, La Jolla, Calif., April 5.
- 6. SIO Reference No. 83-4, La Jolla, Calif., April 1983)
- M. M. Rienecker assisted in the data processing and in the critique of this report. The Office of Naval Research (Physical Oceanography Program) supported this research.

Structural and Bonding Changes in **Cesium Iodide at High Pressures**

Abstract. Cesium iodide, a simple ionic salt at low pressures, undergoes a secondorder transformation at 40 gigapascals (400 kilobars) from the cubic B2 (cesium chloride-type) structure to the body-centered tetragonal structure. Also, the energy gap between valence and conduction bands decreases from 6.4 electron volts at zero pressure to about 1.7 electron volts at 60 gigapascals, transforming cesium iodide from a highly ionic compound to a semiconductor. The structural transition increases the rate at which the band gap closes, and an extrapolation suggests that cesium iodide becomes metallic near (or somewhat above) 100 gigapascals. Similar changes in bonding character are likely to occur in other alkali halides at pressures above 100 gigapascals.

Alkali halides are considered to be archetypal representatives of simple ionic bonding (1). Among these salts, CsI is of particular interest because its high compressibility allows the bonding forces to be probed over a substantial range of interatomic distances (2). The effect of pressure on ionic bonds should therefore be especially pronounced in this compound, and should not be obscured by crystal-structural transformations. This is because CsI at zero pressure is already in the high-pressure structure of the alkali halides: the B2 or CsCltype structure (3). Indeed, on the basis of

geometric packing, the B2 structure is thought to be the highest pressure phase accessible to the alkali halides (3). This is in accord with existing shock wave data that show no evidence for a first-order structural transition in CsI to a volume compression of 0.47 (4, 5).

Cesium iodide is isoelectronic with xenon, which has recently been the subject of considerable attention (6). The behavior of xenon and the other noble gases at high pressures is of theoretical interest because of the expectation that significant changes in bonding character occur under sufficient compression.

Thus CsI may provide some interesting insights as an analog: in the ionic model, Cs^+ and I^- are closed-shell atoms. Experimental and theoretical results suggest that the bonding in this compound changes dramatically between pressures of 0 and 100 GPa (1 Mbar) (7-9).

We studied CsI to pressures in excess of 60 GPa by means of the diamond anvil cell (10). The pressure-volume relation,

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Fig. 2 (left). Plot of the pressure dependence of the structural distortion in CsI. Below 40 GPa the crystal is in the cubic B2 structure and the ratio of lattice parameters c and a is 1. Above 40 GPa the increase of the c/a ratio with pressure shows that CsI undergoes a second-order phase transition that is a progressive distortion from

determined by x-ray diffraction (11), is illustrated in Fig. 1. Above 40 ± 1 GPa the cubic CsCl-type structure distorts to a structure of lower symmetry, which we identify as the closely related body-centered tetragonal (BCT) structure (12). Our data were collected with both increasing and decreasing pressure, and the degree of nonhydrostaticity varied from one run to another with no resolvable effect on the amount of distortion (10). The transition is reproducible with essentially no hysteresis, and there is no evidence that it is caused (or enhanced) by the presence of nonhydrostatic stresses. We believe that this is the first observation of such a distortion of the crystal structure among any of the alkali halides (13).

Two things are unusual about this structural transition: it involves no volume change (within our resolution) and it is of second order. That is, the tetragonal distortion increases continuously with increasing pressure (Fig. 2). The effect of the distortion is to increase the nearest neighbor distance and decrease the second-nearest neighbor distance (the a parameter) relative to the corresponding bond lengths that would occur in the cubic structure at the same volume. This increase in nearest neighbor distance (up



Fig. 3 (right). Change in the energy of the absorption edge or optical gap of CsI under pressure, shown as a cubic to tetragonal symmetry. function of nearest neighbor distance and, where indicated, second-nearest neighbor distance. The gap decreases from 6.4 eV at zero pressure to 1.7 eV at the highest pressure for which data were collected (60 GPa, first-neighbor bond length of 317 pm). The optical changes are reversible, with no hysteresis as pressure is increased or decreased. Our high-pressure data are in general agreement with theoretical calculations (shaded region) (9) and with independent experiments (thin lines, dashed where extrapolated) (8); the lower line represents the published values and the upper line is our reinterpretation of the same data (19). There is a distinct increase in the rate at which the band gap closes as a function of nearest neighbor distance after CsI distorts to the tetragonal structure. When plotted as a function of second-nearest neighbor distance, however, there is no evidence that the rate of gap closure changes across the structural transition (we show a straight line through the data for simplicity, despite our expectation that it curves downward with increasing compression). An extrapolation of our data is consistent with the theoretically calculated result that CsI becomes a metal at a pressure near or somewhat above 100 GPa (first-neighbor distance of 299 pm).

Optical gap energy (eV)

to about 5 percent at 60 GPa) may help stabilize the structure at high pressures; however, it is also possible that the tetragonal distortion is related to changes in bonding under compression.

Our pressure-volume data to 60 GPa (Fig. 1) are in excellent agreement with a finite-strain equation of state based on the elastic constants measured at low pressures (2). This illustrates our conclusion that the distortion from CsCl-type to BCT structures occurs at constant volume. In fact, we see no effect of this transition on the first three derivatives of the pressure-volume relation for CsI. The agreement between our data and the equation of state derived from the elastic constants is of further interest because it provides strong experimental support for the Eulerian finite-strain formalism (14). To our knowledge, these results for CsI represent the largest range of compression $(1 \ge V/V_0 \ge 0.5)$ for which the finite-strain theory has been shown to be successful (15).

With increasing pressure, the absorption edge of CsI shows a large shift to lower energies, moving from ultraviolet frequencies through the visible and into the infrared (8). Thus CsI transforms from a highly ionic compound at low pressures to a semiconductor and ultimately a metal at high compression (6-9). We studied this transformation by measuring the optical absorption spectrum of CsI under pressure (16). The results, summarized in Fig. 3, demonstrate that the energy gap between the valence and conduction bands decreases from 6.4 eV at zero pressure (17) to about 1.7 eV at 60 GPa. There is, however, a slight ambiguity in relating the observed absorption-edge energy to the actual band gap because of the possible effects of excitons (18). Nevertheless, our data provide an estimate of the band gap, and the quantitative difference is not likely to be large.

The band gap in CsI corresponds to a direct, Brillouin zone-center transition from the full valence band that consists mainly of iodine 5p states to the empty conduction band, consisting mainly of cesium 5d states (17). This picture remains valid at high pressures (9), although complexities exist in detail because of the mixing of electronic states as well as the occurrence of the structural distortion.

The optical gap as a function of nearest neighbor bond length is in general agreement with the results of theoretical calculations (9) that lead to the prediction that CsI becomes metallic at or somewhat above 100 GPa (Fig. 3). Our data are also consistent with previous experimental results (19), but we find a distinct change in the rate of gap closure after the tetragonal distortion sets in.

In the BCT structure the energy gap decreases more rapidly with decreasing first-neighbor distance than in the cubic (B2) structure (Fig. 3). This may be attributable in part to the lowered symmetry of the crystal structure, which may increase the widths of the valence and conduction bands. We believe, however, that the more rapid band closure is largely due to the interaction between second-nearest neighbors. That is, the tetragonal distortion results in shorter second-nearest neighbor distances (at a given volume), which causes the valence and conduction bands to broaden in accordance with the Pauli exclusion principle. Hence the gap decreases in response to the decreasing anion-anion (and perhaps cation-cation) distance with compression. One argument in favor of this suggestion is that the optical gap appears to decrease continuously with secondnearest neighbor distance without being affected by the structural transition (Fig. 3). This is in qualitative agreement with theoretical expectations.

On the basis of their properties at low pressures, the alkali halides have traditionally been considered to be relatively simple ionic solids. Nevertheless, with sufficient compression a salt, CsI, can exhibit unusual optical and structurproperties associated with drastic al changes in bonding character (from highly ionic to semiconducting in this case). Similar phenomena undoubtedly occur in the other alkali halides but, because of their lower compressibilities, take place at higher pressures than those used in this study.

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References and Notes

- 1. L. Pauling, *The Nature of the Chemical Bond* (Cornell Univ. Press, Ithaca, N.Y., 1960); C. Kittel, *Introduction to Solid State Physics* (Wi-
- ley, New York, 1967).
 G. R. Barsch and Z. P. Chang, in Natl. Bur. Stand. (U.S.) Spec. Publ. 326 (1971), pp. 173–
- 189. Crystal chemical systematics demonstrate that with increasing pressure (or decreasing tempera-ture) the alkali halides typically transform successively from B3 (ZnS-type) to B1 (NaCl-type) to B2 (CsCl-type) structures [C. W. F. T. Pistor-ius, Prog. Solid State Chem. 11, 1 (1976); A. F. Wells, The Third Dimension in Chemistry (Clarendon, Oxford, 1956); Structural Inorganic Chemistry (Oxford Univ. Press, New York, Chemistry (Oxford Univ. Press, New 1975)].
- S. P. Marsh, Ed., LASL Shock Hugoniot Data (Univ. of California Press, Berkeley, 1980), p. 259
- A volume compression of 0.47 is achieved at a shock pressure of about 100 GPa (1 Mbar).

Although no solid-solid transitions are evident in the data, melting may occur below this pressure

- under shock loading. M. Ross and A. K. McMahan, *Phys. Rev. B* 21, 1658 (1980); in *Physics of Solids Under High Pressure*, J. S. Schilling and R. N. Shelton, Eds. (North-Holland, New York, 1981), p. 161; J. M. (Norm-rionand, New York, 1981), p. 161; J. M. Besson, J.-P. Itie, G. Weill, I. Makarenko, J. Phys. Lett. (France) 43, L401 (1982).
 L. A. Gatilov and L. V. Kuleshova, Sov. Phys. Solid State 23, 1665 (1981).
 V. Accurational V. V. (1981).
- 8.
- K. Asaumi and Y. Kondo, Solid State Commun. 40, 715 (1981). 9
- Aidun and M. S. T. Bukowinski, ibid., 47, 855 (1983)
- Powdered samples of 99.9 percent purity were compressed in a Mao-Bell-type diamond cell with a gasketed configuration [H. K. Mao, P. M. Bell, K. J. Dunn, R. M. Chrenko, R. C. Devries, 10. Rev. Sci. Instrum. 50, 1002 (1979)]. All experi-ments were carried out at room temperature, and pressure was calibrated by means of the ruby-fluorescence scale [J. D. Barnett, S. Block, G. J. Piermarini, *ibid.* 44, 1 (1973); H. K. Mao, P. M. Bell, J. W. Shaner, D. J. Steinberg, J. Appl. Phys. 49, 3276 (1978)]. Various degrees of nonhydrostatic stress were achieved denend. of nonhydrostatic stress were achieved depend ing on the detailed gasket and sample configuration and on whether a pressure medium (mineral oil) was used. The largest deviation from hy-drostaticity in these experiments caused a pressure variation of 10 percent across the sample (for example, \pm 3 GPa at a mean pressure of 60 GPa). Further details will be given by E.K. and R.J. (in preparation).
- 11. Debye-Scherer patterns were collected on film by using collimated Mo K_{α} radiation from a rotating-anode x-ray generator (K_{β} radiation was also used in several experiments). A graph-ite monochromator or Zr filter was used in some but not all runs. The sample-to-film distance was determined from runs at or near zero pressure (the lattice parameter of CsI is 456.79 pm at zero pressure). Two to five of the following diffrac-tion lines were read in the high-pressure runs: (110), (200), (211), (220), (310), and (222). The most intense lines, (110) and (211), were observed in all runs, but the lower intensity (200) was obscured in many of the runs by
- diffraction lines from the gasket. Above 39 GPa, the (110) diffraction line of the 12. B2 pattern splits into two lines which we identify as the (101) = (011) and (110) lines of the BCT pattern. The intensities of these lines and the position of the (211) line (which is shifted from its position in the B2 diffraction pattern) are consistent with this interpretation. The pattern is inconsistent with that of a hexagonal closestpacked structure. A structure with symmetry lower than tetragonal would produce more dif fraction lines than we observe in any of our high-pressure data. The a and c parameters of the BCT structure were determined from the (110) line and the (101) and (211) lines, respectively.
- 13. During the preparation of this report we were made aware of an independent study that corroborates this general result (K. Asaumi, in preparation).
- F. Birch, Phys. Rev. 71, 809 (1947); J. Geophys. Res. 57, 227 (1952).
- _____, J. Phys. Chem. Solids 38, 175 (1977); J. Geophys. Res. 83, 1257 (1978); D. L. Heinz and 15. R. Jeanloz, J. Appl. Phys., in press. A monochromator with a holographic grating
- 16. (dispersion, 12 nm/mm) and a silicon detector were used with a 100-W tungsten-halogen light source to measure the absorption spectra through the diamond cell. The spectral resolution of this system is about 10 nm, and we could measure absorption coefficients in the range 10 to 10^4 cm⁻¹ with an uncertainty of 5 to 10^{-1} measure absorption coefficients in the range 10^o to 10^4 cm⁻¹ with an uncertainty of 5 to 10 percent. Samples were polycrystalline (grain size $\ge 1 \ \mu$ m) and ranged between 8 and 12 μ m in thickness. Selective absorption by the diamonds and by grain-boundary scattering was normalized by referencing the high-pressure data against spectra run at low pressures. We were weable to measure reflections of the sector were unable to measure reflectance spectra with our system and were limited to wavelengths between 400 and 800 nm because of absor by the diamonds at short wavelengths and detector insensitivity at long wavelengths. Further details will be provided by E.K. and R.J. (in preparation)
- Y. Onodera, J. Phys. Soc. Jpn. 25, 469 (1968). 18. Exciton absorption can cause the absorption edge to begin at an energy that is lower than that of the band gap. We observe, however, a rela-tively sharp edge, without a significant absorption tail to complicate our analysis of the spec trum. Based on the spectrum at low pressure

(17), we expect the band gap energy to exceed the energy of the optical gap by no more than about 0.5 eV.

19. We reinterpreted the spectra of Asaumi and Kondo (8) by identifying the absorption edge with the optical gap, rather than choosing the energy at an arbitrary optical density, as was done by the aforementioned. Their spectra are less complete than ours and therefore may be more influenced by exciton absorption (18). Nevertheless, there is relatively good agreement

between both sets of data. We thank J. Aidun, J. M. Besson, M. S. T. Bukowinski, A. K. McMahan, and the review-20 ers for their helpful comments and D. Heinz for his assistance with the experiments. Supported by the National Science Foundation. R.J. is an A. P. Sloan Foundation Fellow

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Carbon Compounds in Interplanetary Dust: Evidence for Formation by Heterogeneous Catalysis

Abstract. Associations of carbonaceous material with iron-nickel alloy, carbides, and oxides were identified by analytical electron microscopy in ten unmelted chondritic porous micrometeorites from the earth's stratosphere. These associations, which may be interpreted in terms of reactions between a carbon-containing gas and catalytically active dust grains, suggest that some of the carbon in the chondritic porous subset of interplanetary dust was emplaced through heterogeneous catalysis.

Chondritic meteorites contain up to 4 percent carbon, mostly in reduced form as organic compounds and elemental carbon, and to a lesser extent in oxidized form as carbonates (1). The nature and origin of these phases are subjects of considerable interest because they are clues to the evolution of carbon during and possibly before formation of the solar system. New insight into the origin of carbon in meteoritic materials is provided by the study of micrometeorites, unmelted interplanetary dust particles (typically $< 50 \mu m$) that are routinely collected in the stratosphere. It is thought that a significant fraction of micrometeorites are of cometary origin since comets are major contributors of dust to the interplanetary medium (2). We report here the results of a study of micrometeorites that are termed chondritic porous (CP); the particles are carbon-rich (> 2 percent by weight) aggregates with chondritic (solar) elemental composition (3). We consider them to be a type of chondrite that has not been found as a conventional-size meteorite, probably because the material is too fragile to survive atmospheric entry in sizes larger than dust. In addition to their porosity, CP micrometeorites differ from carbon-rich carbonaceous chondrites in that the major silicate phases appear to be anhydrous, as determined by electron diffraction and infrared studies (4).

Using analytical electron microscopy (5), we examined carbon-bearing phases in ten CP micrometeorites. Our imaging techniques (in conjunction with electron diffraction) were bright-field, dark-field, and high-resolution lattice fringe imaging. Where possible, collaborative chemical information was provided by x-ray energy-dispersive spectrometry (EDS)

and energy-loss spectroscopy (ELS). As observed previously (6), much of the carbon appeared to be amorphous in the form of mantles, filaments, discrete grains, and matrix material in heterogeneous mineral aggregates. Although most of it was not detectably crystalline (7), we observed minor amounts of poorly crystalline graphitic carbon in some of

Fig. 1. (A and B) Electron micrographs of a hexagonal iron-nickel carbide grain (from micrometeorite Oz) embedded in a carbonaceous mantle. (A) Bright-field image (substrate is a thin carbon support film). (B) Highresolution lattice fringe image of the grainmantle interface. The carbide grain [defined by 2.1-Å (011) fringes] is rimmed by ~ 25 Å of graphitic carbon [defined by 3.4-Å (002) fringes], which merges into the bulk of the amorphous mantle (upper right). (C) A [110] SAED pattern from an orthorhombic ironnickel carbide (from Oz). The predominantly strong supercell reflections (indexed) and weaker subcell reflections arise as a result of an ordered arrangement of interstitial carbon atoms in the carbide crystal lattice. (D) A [100] SAED pattern from an iron-nickel alloy (kamacite) grain. The superimposed ring pattern is due to Fe₃O₄ (magnetite) decorating the alloy grain.

the micrometeorites (Fig. 1, A and B). The amorphous material evidently was not elemental carbon, since ELS indicated minor amounts of nitrogen and oxygen along with the carbon. (It was not possible to determine the extent to which the nitrogen and oxygen measurements were influenced by contamination.) The material could also be unstable under electron irradiation, suggesting that it contained organic compounds or other volatile phases. In typical micrometeorites the carbonaceous material represented only a minor fraction of the particle, although in some micrometeorites discrete grains of low-atomic-number material may have occupied a major fraction of the particle volume.

Carbon was also a constituent of the iron-nickel grains (4 to 8 percent nickel) that usually accounted for < 1 percent of the mass of the micrometeorites examined. Almost all the iron-nickel grains studied contained significant amounts of interstitial carbon. These grains ranged in size from 0.05 to 1.0 μ m and were usually embedded in carbon or "chondritic" material. For these reasons, selected area electron diffraction (SAED) identifications reported here are generally based on the successful indexing of a single zone axis pattern and on the verification of inconsistency between that pattern and patterns possible with a range of alternate candidate structures. Figure 1, A and B, shows hexagonal (epsilon) carbide; Fig. 1C shows an SAED pattern (for an orthorhombic carbide) that exhibits superlattice reflections, suggesting an ordered arrangement of interstitial carbon in the iron-nickel carbide crystal lattice (8). In micrometeorite CP 22 we identified cohenite, an iron-nickel carbide with yet another orthorhombic structure (8). Other grains had cubic structures: for example, the SAED pattern shown in Fig. 1D (a grain from particle CP 22) corresponds to the bodycentered cubic iron-nickel alloy (kamacite). We also characterized an ironnickel grain (in particle SP 61) with facecentered cubic (FCC) iron structure. Because FCC alloy (< 10 percent nickel by weight) is not stable at room temperature, we interpret this latter structure in terms of the FCC carbide (austenite), which has a similar crystal structure and is more stable than the alloy (9). At least three of the carbides have been observed by others: Christoffersen and Buseck (10) reported hexagonal (epsilon) carbide in one micrometeorite, and Fraundorf (11) observed both orthorhombic cohenite and an iron-nickel grain with FCC austenite structure. Finally, bright-field and dark-field imaging experiments and