similar results. In a certain sense these experiments are complementary in that Rutherford scattering is elastic scattering on the nucleus, while Compton/DuMond scattering is *inelastic* scattering on the atom as a whole, but *elastic* scattering on the atomic electrons. The former constitutes the basic discovery of the structure of the atom, while the latter constitutes measurements of a dominant feature of the dynamics of that structure.

The above discussion has dealt with scattering by a *single* electron. Naturally, if more than one electron is involved, the situation becomes more complex. This complication arises if the wavelength of the incident radiation is comparable to the size of the distribution of the electrons. In that case, the scattering of the light by the individual electrons produces interference effects similar to those observed when visible light scatters off the individual elements of a diffraction grating. In general, one can separate the observed scattering into two factors: one is the term that governs the probability of scattering of the X-rays from an individual electron, and the other is the factor which measures the interference effect due to the multiplicity of scattering sources; the latter is known as a 'form factor'. We will meet this type of factorization again when we talk about scattering at much higher energies.

4. High energy electron scattering

Now let us switch from X-rays to electrons for the incident beam and go forward in time by about four decades and up in energy of the particles to be scattered by a factor of about a million. Scattering again can be both elastic and inelastic. Elastic scattering yields information on the radius and general distribution of charge within the proton and neutron. It was elastic electron scattering experiments during the 1950s, for which Robert Hofstadter received the Nobel Prize in 1961, which determined these basic parameters. The fact that the proton has a finite radius indicates in itself that the proton cannot be an ultimate constituent of matter, but rather must have a substructure of some kind. The general nature of this substructure was revealed through experiments at The Stanford Linear Accelerator Center, SLAC, beginning in 1967, which concentrated primarily on inelastic rather than elastic scattering, that is, interactions in which the proton is disintegrated in consequence of the scattering process.

Figures 6 and 7 show, first schematically and then as an actual photograph, the apparatus that was used at SLAC to study both inelastic and elastic scattering of electrons of energy up to 20 GeV on hydrogen targets. Note that the basic components of this apparatus are the same as the ones used by Rutherford. We have an incident *beam* of charged particles; we have a scattering *target*, here consisting of a chamber containing liquid hydrogen; and we have a *detector* composed of magnetic spectrometers which measure precisely the angle of scattering and the energy and nature of the scattered particle. Thus the basic components of a scattering experiment have remained the same throughout this century, as has the spirit of the investigation: Rutherford wished to investigate the substructure of the atom, while the SLAC experiments investigated the substructure of the proton and neutron, which had been established as the fundamental building blocks of the nucleus discovered by Rutherford. While the basic nature and motivation of the experiments have not changed, the scale indeed has. This is a consequence of the uncertainty principle: in order to study matter at smaller dimensions, the transfer of momentum has to be proportionately larger. Roughly speaking, the proton has a diameter one hundred thousand times smaller than the atom, and therefore the energies have to be increased roughly in that proportion.