Chapter 10 WRU Experiment Takes Off

McCarthy, Beth, Meeks, Major, Winter
1937-56 1946-57 1948-55 1955-66 1951-54

Harry Mountcastle was the mainstay of the Western Reserve department for forty years, having been hired at age 32 by chairman Whitman in 1907. While Mountcastle had done some atomic spectroscopy early in his career, he was principally concerned with undergraduate teaching. He had, at most, the aid of one or two junior faculty. He succeeded Whitman as chair in 1919. He was assisted in the late 1930's by Cassius Curtis (Chapter 5). In 1937, Mountcastle was joined by John McCarthy who would remain in the department for two decades.

At the beginning of Chapter 7 we commented on the rapid growth in research funding which occurred during and following the second world war. The impact on the two physics departments was enormous, leading to the significant expansion of each. When the two institutions federated in 1967, largely as a result of pressure by the funding agencies, it would be the WRU physics faculty who would be most affected by the subsequent downsizing of the new CWRU department.

Fig. 10-1. John T. McCarthy.

McCarthy: the new electronics

John McCarthy (born 1912 in Canandigua, NY, BS Hobart College 1934) was hired in 1937 soon after completing his doctorate at Yale. **Fig. 10-1.** His dissertation was a study of α scattering by Ne and D atoms in a Wilson cloud chamber. From the observation of 600,000 tracks of α's from a thorium source, McCarthy found 25 examples of elastic scatters by neon nuclei and 30 by deuterons. From the measurement of the scattering angles and the lengths of the recoil tracks in the stereoscopic photographs, he was able to produce range vs. velocity curves for recoil neon ions and deuterons. (There is no mention of how much charge is on the neon ions; the plotted data look like they were all equally ionized, presumably singly.) These are shown in **Figs. 10-2 and 10-3**, where the ranges have been rescaled to air at one atmosphere. This was cutting-edge work in nuclear physics for the time, making use of the radiation sources and the detector technology available in the 1930's. (*Phys. Rev.* **53** 30 1938) (Twenty years later, I was another Yale grad student, analyzing thousands of proton-proton collisions in an accelerator-based *bubble* chamber experiment.)

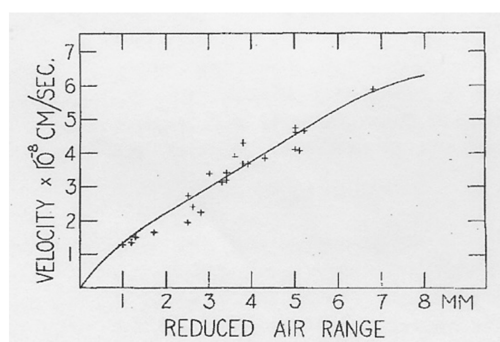

Fig. 10-2. Velocity vs. range for neon ions.

At Western Reserve, McCarthy and Chairman Mountcastle were responsible for most of the physics teaching duties in the period before and during the world war. In the mid-1940's, McCarthy became interested in electronics and the development of teaching-laboratory instrumentation. He published papers on improvements in vacuum-tube voltmeters and current stabilizers. His expertise with electronic circuits brought him into several collaborations, including one on electrolytes with Ernest Yaeger and Frank Hovorka of the chemistry department. McCarthy's main contribution was a circuit which produced ultrasonic waves.

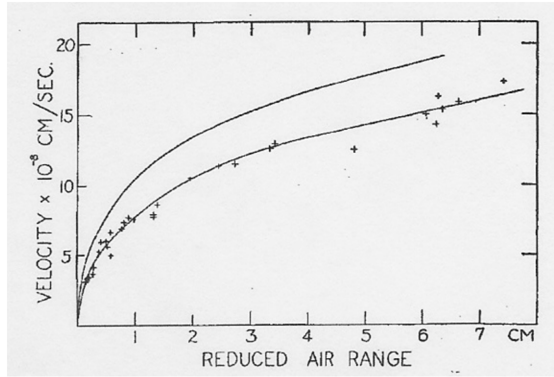

Fig. 10-3. Velocity vs. range for deuterons.

Chairman Mountcastle retired in 1945 and McCarthy would be the be the bridge to the new, post-war department, under the chairmanship of Richard Beth.

In a 1950 paper, McCarthy describes how he used the timing signals broadcast by the Bureau of Standards to calibrate a pendulum clock. (He mentions that the laboratory standard clock was out for repair.) The government had been broadcasting timing signals over their dedicated radio station, WWV, since 1920. McCarthy developed a vacuum-tube receiver and relay combination which would produce an audio signal when the pendulum and the WWV signal came into coincidence. He was essentially "beating" the two signals against one another. The pendulum turned out to have a period of about 1.0033 s, which means that it would get into phase with the WWV signal about once every five minutes. The observer would just measure the time between the "coincidence clicks" to determine the difference between the pendulum and WWV frequencies. The resulting measurement of the period was good to three parts per million. McCarthy concludes that using the WWV signals produced data "more consistent and reliable" than using the standard clock. That would hasten the demise of pendulum clocks as standards. *Amer. J. of Phys.* **18** 306 1950.

TABLE I. Mass differences for stable isobars which are most likely to exhibit double-beta disintegration.

A		ΔM_{calc} mMU	ΔM_{exp} mMU	Ref.
48	Ti—Ca	−4.50	−4.66	a
76	Se—Ge	−1.86	−2.5	b
78	Kr—Se	2.80	3.19	b
82	Kr—Se	−3.04	−2.7, −3.5	b, c
96	Mo—Zr	−4.12	−3.6	b
96	Ru—Mo	3.12	3.0	b
100	Ru—Mo	−2.48	...	
106	Cd—Pd	3.16	3.0	d
116	Sn—Cd	−2.96	−2.7	d
124	Te—Sn	−2.24	−2.1	d
124	Xe—Te	3.14	3.0	d
130	Xe—Te	−2.60	−3.5, −2.9	d, e
130	Ba—Xe	2.66	2.74	f
136	Ba—Xe	−2.76	...	
136	Ce—Ba	2.26	...	
150	Sm—Nd	...	−4.3	g

Fig. 10-4. Searching for candidates for double beta decay.

McCarthy found the time in the mid-1950's to do some nuclear physics research. This work was an effort to identify those nuclei which might possibly decay by the simultaneous emission of two electrons (called double beta decay). He collected all the available information on the masses of pairs of stable nuclei having the same atomic mass number, A, but with atomic charge numbers, Z, differing by two units. In his Table (**Fig. 10-4**), he lists sixteen such isobaric pairs, along with the experimental mass difference (in milli-atomic mass units) and the theoretical mass difference based on the Wigner mass formula. In most cases, the experimental and theoretical mass differences were quite close. Ten of the states could decay by emission of two electrons (ΔM negative) and six by emission of two positrons (ΔM positive). (*Phys. Rev*. **95** 447 1954**)** Later in this chapter, we shall describe experimental searches performed in 1955 by another young experimenter, Rolf Winter. (In Chapter 8 we described an experimental search for double beta-decay done a decade later by Tom Jenkins in the low-background environment of a salt-mine.)

McCarthy left WRU in 1956 to take a position at the University of Cincinnati where he would spend the rest of his teaching career.

Beth: the angular momentum of light

Fig. 10-5.
Richard A. Beth.

In 1946, 38-year-old **Richard A. Beth** was appointed the seventh Perkins Professor and chair of the WRU physics department. (Seventy-year-old chairman Mountcastle had stepped down the previous year, and Professor Frank Hovorka of the chemistry department was acting chair of physics.) Beth was born in New York City, did his BS at Worcester Polytechnic Institute in 1929 and a Doctorate of Natural Philosophy in Frankfurt in 1932. He taught at WPI for eight years while working in research at Princeton. During the war he was head of a group studying "terminal ballistics and explosive effects" for the National Defense Research Commission. His photo is shown in **Fig. 10-5.**

At Princeton Beth designed and executed an important and historical experiment. While this work was done before Beth came to WRU, we shall describe it briefly. No doubt, it had a lot to do with his being offered the job. The idea was to send a beam of polarized light through a doubly refracting quartz plate suspended from a fine quartz fiber. Since the plane of polarization is rotated as the light passes through the quartz, one expects to observe a torque on the plate. This can be measured by observing the twisting of the suspension. In the diagram, **Fig. 10-6**, one can see the illuminating filament at the bottom, the parallelogram shaped Nicol prism which polarized the light, the suspended quartz disk (M), and a fixed disk (T). This second disk was silvered on its top to reflect the beam back through M, after shifting the phase of the light in such a way that the reflected light would re-enforce the torque on M. The measured torques were in the order of 10^{-9} dyne-cm. They were compared with theoretical values calculated from the measured intensity of the light, the rate of energy deposited in the disk, and the amount of rotation of the plane of polarization. The measurements were made for different light intensities and for different directions of polarization. In all cases the observed torque agreed with the calculated value. This 1936 experiment was the first direct observation of the angular momentum associated with a beam of polarized light. (*Phys. Rev*. 48 471 1935, and *Phys. Rev*. 50 115 1936) "Mechanical Detection and Measurement of the Angular Momentum of Light".

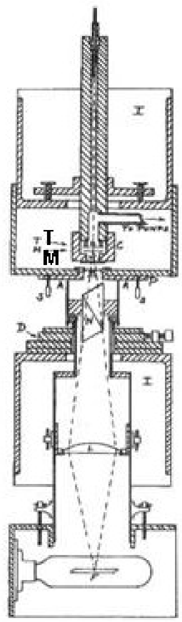

Fig. 10-6. Observation of the angular momentum of a beam of light.

At WRU, Beth took an interest in a very different area: the mathematical analysis of stress and deformation in structural elements, e.g. the bending of beams under loading. He, along with two collaborators, published papers on the subject in the Journal of Applied Physics and the Journal of Applied Mechanics. He soon returned to the question of the mechanical effects of electromagnetic waves In 1952, he and Wilkison Meeks submitted a proposal to the Office of Naval Research to improve upon the 1936 experiment.

Beth stepped down as chairman in 1955 when John Major arrived to take over that responsibility. Beth subsequently took an extended leave to go to Brookhaven Laboratory. He and assistant professor Wilkison Meeks collaborated on the investigation of the focusing action of wave guides to be used in the alternating gradient proton accelerator. The AGS would become the centerpiece of the particle physics program at BNL. By 1957, Beth had decided to resign his professorship and to take a position at Brookhaven where he became part of the AGS design group.

Meeks: the teaching labs

Wilkison Winfield Meeks (born in 1915) was hired by Beth as an assistant professor in 1948. **(Fig. 10-7)** He had spent the war years at the Naval Ordnance Laboratory. He had then completed his PhD at Northwestern University in 1947. His dissertation was on the properties of the nucleus of columbium, ^{93}Cb. "Hyperfine Structure and Nuclear Moments of Columbium" *Phys. Rev.* **72** 451 1947.

Fig. 10-7. Wilkison W. Meeks.

Meeks was to be a member of the WRU faculty for eight years, responsible for a large portion of the teaching duties. Chairman Beth wrote in Meeks' evaluation that he had taught expertly in nine different laboratory courses, including setting up three new labs. He was appointed University Marshall (antecedent to physicist Keith Robinson's appointment forty years later, cf. Chap. 16). During his tenure he worked with Beth on the design and construction of a device to measure the torque in a rotating shaft. The idea is based on the fact that the magnetic permeability of iron changes slightly if the sample is subjected to tension or compression. The application of torque to a shaft produces both tension and compression in the shaft which increase linearly with radius. In their invention, Meeks and Beth placed driving and pickup coils near the torqued shaft, so that the B field caused by a 500 Hz current in the driver is picked up by a galvanometer circuit on the opposite side of the shaft. The response on the galvanometer (deflection in mm in **Fig. 10-8**) was remarkably linear as a function of torque (shown in inch-lb). They applied for a patent for this invention in 1952. "Magnetic Measurement of Torque in a Rotating Shaft" *Rev. Sci. Instr.* **25** 603 1954.

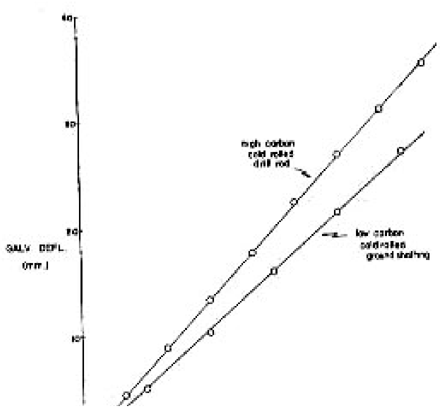

Fig. 10-8. Magnetic measurement of the torque on a shaft.

Meeks became interested in speech synthesis and presented papers on this subject at meetings of the Acoustical Society of America. He resigned his position at WRU in 1955 to go to the B.F. Goodrich Research Labs.

Winter: double beta decay

Rolf Gerhard Winter joined the Western Reserve department as instructor in 1951, just after receiving his doctorate from Carnegie Tech. **Fig. 10-9**. The 23-year old, Düsseldorf-born Winter had done his doctoral research on double beta decay. His thesis is a classical combination of theory and experiment. He had worked at Carnegie with E. Creutz and Lincoln Wolfenstein. "A Search for Double Beta Decay in Palladium" *Phys. Rev.* **85** 687 1953.

Winter continued this work at WRU and was promoted to assistant professor in 1952. As we described in Chapter 8, the theoretical interest in double beta decay concerned the "neutrinoless decay" hypothesis: if the neutrino is its own antiparticle, then the two neutrinos emitted along with the two electrons can devour one another. In a typical one of Winter's "runs", 42 grams of thin molybdenum foil were placed in a 24-cm diameter Wilson cloud chamber which was in a magnetic field of 790 Gauss. The chamber was expanded every 30 seconds, or so, until about 12 thousand stereo photographs were taken. The pictures were scanned for events in which either two electrons or two positrons were seen to come from the same point in the metal foil. Of the few dozen candidates, only one or two events had the total energy expected in the sought-after decay. Knowing the total number of atoms in the foil and the total amount of time during which the chamber was sensitive, Winter was able to place lower limits on the double-beta lifetimes. These were typically

Fig. 10-9.
Rolf G. Winter.

in the 10^{17} years range. Results such as these gave support to the conclusion that the anti-neutrino is different from the neutrino. "Search for Double Beta Decay in Cadmium and Molybdenum" *Phys. Rev*. **99** 88 1955.

While at WRU, ROTC 2nd Lt. Winter was called to active duty in the US Army and many letters between the Defense Department and chairman Beth and even WRU president Millis seem finally to have kept young Rolf out of Korea. After only three years at WRU, however, Winter decided to accept a position at Pennsylvania State University where he remained for about 15 years before going on to spend the rest of his career at the College of William and Mary.

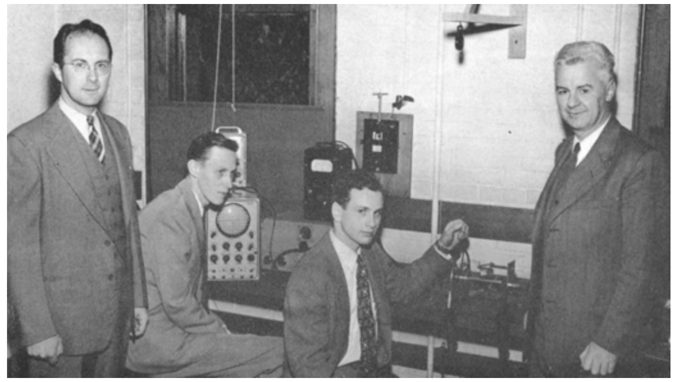

Fig. 10-10. McCarthy, Meeks, Winter and Beth

A photo from the 1954 WRU yearbook shows the four-man WRU physics faculty, with some of their electronics equipment. **Fig. 10-10.**

Fig. 10-11. John Keene Major.

John Major: a new young chairman

John Keene Major came to WRU as an associate professor and chair in 1955. (**Fig. 10-11**) He was only 31 years old, but with the impending departure of essentially all the WRU physics faculty (Beth, McCarthy, Winter and Meeks), new talent was urgently needed. Major had completed his BS at Yale in 1943 and, after a two-year stint in the sonar analysis program at Columbia, he had earned his doctorate under F. Joliot and I. Joliot-Curie at Collège de France in 1951. *(It is possible that he interacted with Shankland or Foldy who were in the underwater acoustics program at Columbia during the same period.)* After a Fulbright in Paris, Major was awarded an NSF Scholarship which took him to Munich to work on Mössbauer spectroscopy. He returned to Yale for a short period to work on a comprehensive compilation of nuclear electron-capture data. (*Rev. Mod. Phys*. **26** 321 1954)

At WRU, Major was able to continue a modest research program on Mössbauer spectroscopy. This technique will be described in Chapter 12. "Recoil-free resonant and non-resonant scattering from Fe^{57}" *Nucl. Phys*. **33** 323 1962. His main activity, however, would be the tripling of the size of the department.

Rapid Expansion

After two years on the WRU faculty, Major was appointed as the eighth Perkins Professor. He was the principal player in the creation of a research-oriented physics department at WRU. With the support of the WRU administration and president John S. Millis, and generous funding from the government in the "Sputnik era", Major transformed a four man department which was principally occupied with the teaching of hundreds of pre-med students into a department of a dozen faculty researchers. The expanded department was housed in the large new Millis Science Center, which they shared with the WRU chemistry and biology departments. (Whitman's 1895 building, described in Chapter 5, was torn down around 1969.) The WRU physics PhD program was initiated during this period and the first doctoral degree was granted in 1962. (E. Brooks Shera wrote his dissertation on experimental nuclear physics under the direction of Berol Robinson, c.f. Chapter 14. The first physics PhD at Case had been granted in 1949 to Earle Gregg, Shankland's student.)

The Western Reserve department was for the first time becoming a worthy rival of the Case department. By 1963, Major's twelve man team and Reines' nineteen man team were beginning gradually to interact. (The dingy restaurant in the basement of Eldred Hall provided a most convenient locale, a few steps from each department.) They had dissimilar missions: one, part of a liberal arts and sciences university, and the other, part of a school of mainly engineering technology. But they had become similar in size and research activity. Each institution submitted a proposal to the National Science Foundation for a multi-million dollar "Science Development Program" grant. One component of the WRU proposal was a Condensed State Center while Case Institute proposed a Center for the Study of Materials. We shall see later how the NSF funding played a role in the eventual union of the two departments and the federation of the two institutions.

It was during John Major's tenure as chairman that all of the seven theorists whose work will be described in Chapter 11 and ten of the experimentalists we shall meet in Chapters 14 and 15 were recruited to the WRU department.

John Major decided to leave Western Reserve in 1966 to take a position with the National Science Foundation in Washington. He was on the executive council of the Federation of American Scientists (a progressive liberal organization which is still active in monitoring the role of science in society). He moved on to administrative positions at the University of Cincinnati, New York University, Northeastern Illinois University. Ultimately, he decided to combine his love for music with his talents in electronics and moved to the world of FM broadcasting. He founded classical music station KCMA at Tulsa, Oklahoma. He died in 2003.