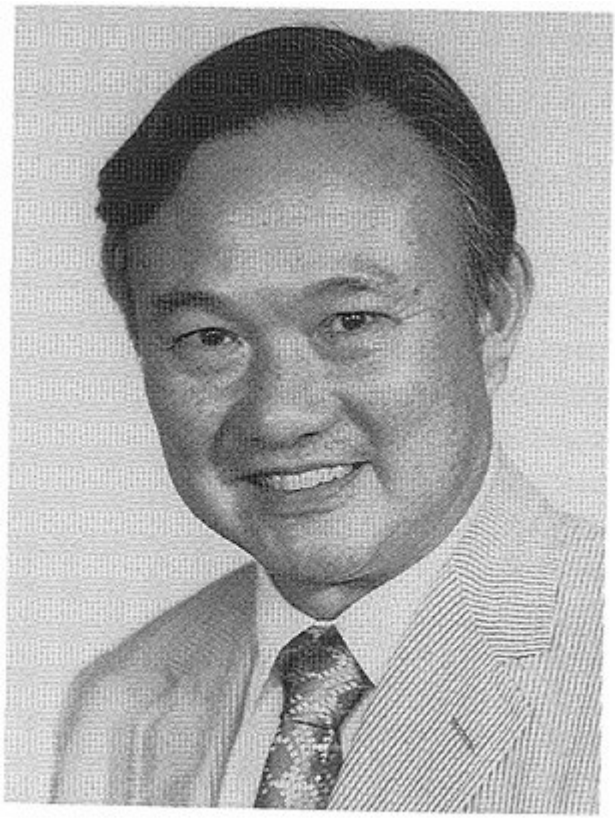

CHIA-SHUN YIH

1918–1997

BY YUAN-CHENG FUNG

CHIA-SHUN YIH was a humane, humorous, and poetic fluid dynamicist. He invented elegant mathematical transformations that simplify the differential equations and boundary conditions of the flow of nonhomogeneous fluids. He devised efficient methods of calculations. He discovered many exact or closed form solutions of waves and instabilities in fluid flow, and of course also many approximate solutions. He devised efficient calculations and pertinent experiments. He developed the field of stratified flow for its beauty and applications to atmospheric, oceanic, and other flows of scientific, environmental, and industrial interest. In his memory, his friends organized an international symposium at the U.S. National Congress of Applied Mechanics in June 1998, and dedicated a book, *Fluid Dynamicsat the Interfaces* (Cambridge University Press, 1999), to him.

Chia-Shun Yih was born on July 25, 1918, in Kweiyang City, Kweizhou Province, which lies in the southern midwest part of China. Kweizhou is a beautiful mountainous country. Chia-Shun was born into a scholarly family, the son of Yih Ding-Jan and Hsiao Wan-Lan. His father was a specialist on silk and silkworm culture. His father's profession was fortunate for me, because it made his father come to work in Kiangsu Province, which lies on the east coast of China, where I was born, where every family raised silkworms in the spring. Chia-Shun attended junior middle school (grades 7 to 9) in Zhengkiang, the provincial capital of

Kiangsu. Then he and I both passed the entrance exam of the Soozhou Senior Middle School (grades 10 to 12) and entered in 1934. Soozhou has a long history. It was the capital of the Kingdom of Woo (585 B.C. to 490 B.C.). Our school ground was old and beautiful. The oldest hall of the school, where we often took examinations, was called the Purple Sun Hall, in honor of Master Zhu Hsi (1130 to 1200 AD). The walls of the hall were lined with plaques of black stone on which Zhu Hsi's poems and lectures were carved. The halo of tradition was real.

While we were in high school, the storm of war was gathering in China. Japan had occupied Manchuria in 1931 and invaded Shanghai in 1932. Full-scale war between China and Japan finally broke out on July 7, 1937, soon after our graduation from high school. We managed to take the entrance examination of the National Central University and got accepted. The university was located originally in Nanjing, the capital of China at that time. Before we could enter, however, it was moved to Chongqing, in Sichuan Province in the central midwest of China.

At our university, Chia-Shun studied, among other things, mathematics and the theory and design of bridges. Our college years were spent in makeshift classrooms and laboratories, classes at the crack of dawn to avoid air raids, long hours in the dugouts, military training, and an endless stream of exciting or sad news. One wintry day, Japanese planes came and bombed out our simple shower hut, and for weeks afterward some of us had to bathe in the emerald water of the nearby Chia-Ling River, beautiful but cold.

After graduation, Chia-Shun worked first in the National Hydraulics Laboratory in Guanshien, Sichuan. There he studied the work of Li Bing, who more than 2,300 years ago, invented a system of constructing and reconstructing control dikes every year, which works to this day. Li Bing's design made Chengdu plain one of the richest areas in China for 2,300 years. Then Chia-Shun worked for the Chinese Bridge Company in Kweiyang, his hometown, designing highway bridges. In 1944 he taught at Kweizhou University. Then he married Loh Hung-Kwei, who gave birth to their first son, Yiu Yo Yih. The marriage lasted only a few years.

Then a group of American professors visited China and upon their return raised forty-some graduate scholarships from various American universities and offered them to the Chinese Ministry of Education. By nationwide examinations, the Ministry of Education chose forty-two students to study in the United States. We were among the forty-two, and in 1945 we came to the United States via India.

After a brief stay at Purdue University, Chia-Shun went to the University of Iowa to study fluid mechanics with Hunter Rouse and John McNown, with whom he maintained a warm friendship throughout his life. He signed up also for courses in music appreciation and French conversation. The young instructor of French conversation was Shirley Ashman from Maine. Chia-Shun and Shirley fell in love and were married in 1949.

In the summer of 1947, Chia-Shun went to Brown University and listened to C.C.Lin's lectures on fluid dynamics and was inspired. On returning to Iowa, he told me that he was concentrating his study on the smoke from a lighted cigarette. The smoke rises, curls up, becomes turbulent, and disperses. He was fascinated. His mentor, Hunter Rouse, encouraged him to pursue the subject in depth. It became a part of his Ph.D. dissertation. From that little seed a whole field grew up in his mind. In the following years, Chia-Shun developed the general theory of the dynamics of nonhomogeneous fluid with broad applications. This beginning of a big endeavor with a small subject is a trait of his research career, consistent with his love of poetry. A poet sees the arrival of spring in a single flower bud. The cigarette smoke contains the same truth and same beauty as the larger subjects.

Chia-Shun got his Ph.D. in 1948. From 1948 to 1955, Chia-Shun taught and conducted research at the University of Wisconsin, the University of British Columbia, Colorado A&M University, the University of Nancy in France, and the University of Iowa. He finally settled down at the University of Michigan in Ann Arbor. For sabbatical leave he went to Europe. He spent a year (1959 to 1960) at Cambridge University, England, a year (1964) in Geneva, another year (1970 to 1971) in the Universities of Paris and Grenoble in France, and a year (1977 to 1978)

at Chatoux Lab in Paris and the Technische Hochschule Karlsruhe, in Germany. After he retired in 1988, he served as a graduate research professor at the University of Florida in Gainesville for three years.

Honors followed Chia-Shun's achievements. In 1968 the University of Michigan celebrated its sesquicentennial and chose to give special honors to a few outstanding professors among its faculty. Chia-Shun was given the title of Stephen P.Timoshenko Distinguished University Professor of Fluid Mechanics. In 1970 he was elected a member of Academia Sinica. In 1980 he was elected a member of the U.S. National Academy of Engineering. He was honored by the Chinese Institute of Engineers with the 1968 Achievement Award and by the Chinese Engineers and Scientists Association of Southern California with the 1973 Achievement Award. In 1974 he was the University of Michigan's Henry Russel Lecturer. In 1981 he was given the Theodore von Kármán Medal by the American Society of Civil Engineers. The American Physical Society gave him the Fluid-Dynamics Prize in 1985 and the Otto Laporte Award in 1989. In 1992 he had the honor to present the Sir Geoffrey Taylor Lecture at the University of Florida. Chia-Shun was a great admirer of Sir Geoffrey. Earlier, in 1976, Chia-Shun had dedicated to Sir Geoffrey a volume of *Advances in Applied Mechanics* that he edited. In the preface, Chia-Shun said of G.I.Taylor, "His work was always marked by an originality of thought and a freshness of approach that continue to delight his readers, and a characteristic welding of analysis to experiments that is rarely attempted, let alone attained, by others." My feeling is that this describes Chia-Shun himself very well.

In daily life the Yih family is warm, relaxed, and somewhat idealistic. Son Yiu Yo is a computer expert, son David is a Ph.D. musician, and daughter Katherine is an ecological biologist working on public health. Chia-Shun played flute and painted with oils in the style of the French impressionists. He was gregarious and a wonderful storyteller. He loved to eat and often cooked for friends. He was a true gardener and could name many plants by their Latin names. He took long walks in the countryside everyday whenever weather permitted. He loved students and

treated them as family members. Inspiration could come to him at any time, in any place. During the garden wedding ceremony of his daughter, he whispered to me that he had suddenly found the solution of a solitary wave.

Chia-Shun enjoyed good health all his life. Two days before his death, he planted five young flowering trees in his garden. Friends watching him digging the holes asked him, why he must dig the holes so big and so deep? He answered, "At my age, I want to make sure that every sapling gets its full share of endowment! None should be shortchanged." On April 24, 1997, Chia-Shun died while on a commercial airline flight from Detroit to Taipei to participate in the Conference on Mechanics and Modern Science at the Academia Sinica. When a stewardess tried to wake him up for a stop at Tokyo, she found him unconscious. The passenger sitting next to Chia-Shun said he did not notice Chia-Shun had any signs of discomfort. Chia-Shun was sent to a hospital immediately after landing, but he never woke up. That was April 25th in Tokyo, the 24th in Detroit.

Chia-Shun's lighted cigarette study found more formal presentations in his Ph.D. dissertation and in his first two papers: one in the *Journal of Applied Mechanics* (1950) under the title of "Temperature Distribution in a Steady, Laminar, Preheated Air Jet," and another in the *Proceedings of the First U.S. National Congress of Applied Mechanics (1950)* under the title of "Free Convection Due to a Point Source of Heat." His formulation of the problem and his solutions were really elegant. The laminar flow solution was exact, and it was accompanied by a systematic experimental investigation on the transition from laminar to turbulent flow. These studies were followed by a series of papers dealing with atmospheric diffusion, gravitational convection from a boundary source, turbulent buoyant plumes, buoyant plumes in a transverse wind, etc. His characteristic approach was to find exact solutions as far as possible, and to check with experimental results. From his first paper to the one hundred thirtieth, the spirit was the same.

Chia-Shun's scientific papers published between 1950 and the early part of 1990 have been collected in a two-volume set called *Selected Papers by Chia-Shun Yih,* published by World Scien

$$\sqrt{\rho}\ u = \partial\psi' / \partial z,\ \sqrt{\rho}\ w = -\partial\psi' / \partial x,$$

$$\nabla^2\psi' + (gz/\rho_0)\, d\rho / d\psi' = (1/\rho_0)\, dH/\partial\psi',$$

gives rise to a variety of interesting natural phenomena. Yih solved problems on the hydraulic jump of layered fluid, atmospheric phenomena, flow in porous media, prevention of stagnation zones in flows of a stratified or rotating fluid, edge waves, vortex rings, internal waves in pipes, similarity of stratified flows, instability driven by viscosity stratification, subharmonic instabilities in modulated viscous flows, long wave analysis of free-surface instabilities, surface-tension modulated waves, etc.

The second category of Yih's papers on the theory of hydrodynamic stability consists of a series of fundamental papers on two-dimensional parallel flow for three-dimensional disturbances, the stability of unsteady flows or configurations, eigen-value bounds for the Orr-Sommerfeld equation, electrically conducting fluids, non-Newtonian fluids, viscosity stratification, and thermal conductivity stratification. This series of basic papers includes his solutions of a number of aeronautical, civil, and manufacturing engineering problems. Examples include the flow down an inclined plane, the waves in the deicing liquid sprayed on an airplane wing to deice the plane in cold winter weather, and waves in the sheet of paper pulp spread on a rotating cylinder in the process of paper making.

The third category of Yih's work is gravity waves. He gave solutions to water waves in basins of variable depth, waves in channels of various cross sections, waves in meandering rivers, edge waves created by a long-shore current and a ridge in the seabed, nonlinear wave groups, and ship waves.

Papers in the fourth category on jets, plumes, and diffusion are especially relevant to environmental concerns. Lighted cigarettes, chimneys, and polluting cities have a lot in common.

Finally, a large number of Yih papers collectively classified as the general category exhibit the breadth of his interest, from pure mathematics to magnetohydrodynamics and biomechanics. Altogether, the *Selected Papers by Chia-Shun Yih* preserves a good record of his journal articles.

In addition, Yih published two books on stratified flows and one on the whole field of fluid mechanics. His *Dynamics ofNonhomogeneous Fluids* was published by Macmillan in 1965. The second edition of this book, which contains a great deal of new

material, was given a new title, *Stratified Flows* (Academic Press, 1980). The Yih style of fresh and concise writing shines through. This style is particularly evident in his third book, *Fluid Mechanics, A Concise Introduction to the Theory* (McGraw Hill, 1969). When this book went out of print in 1979, Chia-Shun issued an improved edition through the West River Press in order to reduce its price for the benefit of students.

Chia-Shun was interested in biomechanics also. In 1968 he and I published a paper together, entitled "Peristaltic Transport" (*Journal of Applied Mechanics,* 1968, pages 669–675). We were aiming to understand a disease called hydroureter, in which the ureter becomes enlarged, the peristaltic transport becomes ineffective, and the kidney injured.

Chia-Shun did not work much further on biological problems. But he laid out a plan to study the blood flow in large arteries by means of the Orr-Sommerfeld equation. When he solved the colliding soliton problem in 1993, we discussed extensively to aim further research on the arterial blood flow problem. There is no doubt that solitons can exist in arteries because of the nonlinear characteristics of the elasticity of the blood vessel wall, which stiffens as the strain increases. But the arterial tree is characterized by its branching pattern, each branch is not very long, and the flow is characterized by the forward and reflected waves. Hence his colliding solitons theory is relevant. Unfortunately, he died too soon.

Chia-Shun's last manuscript was entitled "Tornado-like Flows." One day, after a long drive from Gainesville, Florida, to Ann Arbor, Michigan, he called me to tell me that he and Shirley had arrived home safely; and that while Shirley was driving, he found a mathematical model of a tornado. He added to a swirling horizontal flow of a fluid a core of another fluid of different density and temperature, and a model of a tornado is obtained. In his head, he worked out the mathematical facets of how a core can lead the weather condition at a high altitude to the ground, how the horizontal swirling will generate the maximum speed at the surface of the core at the ground level, how the cyclonic action would cause the tornado to spin counterclockwise looking down toward the earth in the northern hemisphere,

but clockwise in the southern hemisphere, and how sometimes a shaped tornado can be formed. He explains why the debris of a tornado is always thrown to the left in the northern hemisphere. It remained only to check the literature, ask the experts about the facts, do some numerical calculations, and write it up. I have a rough draft of the paper, but I have not succeeded in tracking down its publication.

The *Selected Papers by Chia-Shun Yih* includes only his mathematical and physical articles. His other writings were omitted. I am glad that his "Remembrance of G.I.Taylor" remained in the *Selected Papers* (pages 1005–1009). But I wish you could read his literary piece, "Old China Remembered," published in *TheOhio Review* 18 (1977), pages 67–77, (Bibliography No. 84, *Selected Papers,* page 1020). It consists of five short stories, entitled "The Slate Court," "Crepuschule," "Mulberries," "Silk from Wild Cocoons," and "Winter-Sweet." Through them we would really understand the life and imaginations of young Chia-Shun. Donald Hall, the poet, in his introduction to this article, said, "When I think of Chia-Shun now in his absence, he smiles with a wild enthusiasm—and it may be enthusiasm over a poem a thousand years old, or over a problem he is solving, or over the petal of a flower in front of us. He delights in the…but unlike most humans—scientist or poet or salesman or factory worker—his world moves far outside the borders of his work; it is wide with things to be loved and cherished."

An illustration of Chia-Shun's seeing poetry in fluid mechanics and fluid mechanics in poetry can be found in the frontispieces of his books. He chose a 1946 photograph of a wheat field in western Kansas to illustrate the dynamics of nonhomogeneous fluids and a thirteenth century Chinese painting of a tidal bore to illustrate fluid mechanics, and he quoted the poems of La Fontaine, Li Chong Chu, and Fung Yen Ci to introduce various topics in fluid mechanics. Such a poetic mind was his!

A list of Yih's papers published before 1990 is given in *SelectedPapers by Chia-Shun Yih*. Those published from 1990 to 1997 are presented below.

Yih, C.S.1990. “Wave Formation on a Liquid Layer for Deicing Airplane Wings.”*Journal of Fluid Mechanics,*212: 41–53.
Yih, C.S.1990. “Infinitely Many Superposable Solutions of the Navier-Stokes Equations: Damped Beltrami Flows.” In *Of Fluid Mechanics and Related Matters,* proceedings of a symposium honoring John Miles on his 70th birthday, December 1990.
Yih, C.S.1993. “General Solution for Interaction of Solitary Waves Including Head-on Collisions.”*Acta Mech. Sinica*9:97–101, Science Press, Beijing.
Yih, C.S.1993. “Solitary Waves in Stratified Fluids and Their Interaction.”*Acta Mech. Sinica*9:193–209, Science Press, Beijing.
Yih, C.S.1994. “Solitary Waves in Poiseuille Flow of a Rotating Fluid.”*Quarterly of Applied Mathematics,*52:739–752.
Yih, C.S.1994. “Intermodal Interaction of Internal Solitary Waves.”*Quarterly of Applied Mathematics,*52:753–758.
Yih, C.S.1995. “Kinetic-Energy Mass, Momentum Mass, and Drift Mass in Steady Irrotational Subsonic Flows.”*Journalof Fluid Mechanics,*297:29–36.
Yih, C.S. and Wu, T.Y-T.1995. “General Solution for Interaction of Solitary Waves Including Head-On Collisions.”*Acta Mech. Sinica*11:193–199.
Yih, C.S. and Zhu, S.1996. “Selective Withdrawal from Stratified Streams.”*Journal of the Australian MathematicalSociety, Series B*38:26–40.

Yih, C.S.1996. “Added Mass.”*Chinese Journal of Mechanics,*12:9–14.
Yih, C.S.1997. “The Role of Drift Mass in the Kinetic Energy and Momentum of Periodic Water Waves and Sound Waves.”*Journal of Fluid Mechanics,*331:429–438.
Yih, C.S.1997. “Evolution of Darwinian Drift.”*Journal ofFluid Mechanics,*347:1–11.