

talking about loyalty in the true sense. A consort needs to stand by her spouse no matter what, always present a united face, and be there to listen and advise when the spouse needs it." He added, "It's also very important that the consort act and be seen as a complementary figure rather than a competitive figure. You don't want to run the risk of overshadowing your partner."

Claudia Joseph wrote for the *London Mail on Sunday* (December 30, 2007) that Catherine, who stands at five feet eight inches tall, has a "glossy mane of brown hair, classic English-rose looks and natural, enforced elegance." "There is something quintessentially English and modest about her, which echoes Diana in 1981 [the year she married Prince Charles]," Geordie Greig, the editor of *Tatler*, told David Smith for the *London Observer* (December 31, 2006). "She's elegant and beautiful and a million miles from Hollywood glamour. It is a very particular English rose bearing which cannot be crafted by cosmetics companies."

In June 2011 Catherine and Prince William were in the process of acquiring an apartment in Kensington Palace, in London. (In London they had previously stayed at Prince William's bachelor apartment in Clarence House, the residence of his father, Prince Charles; stepmother, Camilla; and brother, Prince Harry.) The royal couple will continue to live primarily in their house on Anglesey, a Welsh island. Their administrative office is in St. James's Palace, in London. Catherine and Prince William traveled to Canada in July 2011 for their first royal tour of the country, and that same month they appeared before cheering crowds in Los Angeles, California.

—J.P.

Recently, thanks to the controversy stirred up by the so-called Tea Partyers regarding President Barack Obama's place of birth and the authenticity of his birth certificate, newscasters repeatedly noted that United States law requires that candidates for the American presidency must either have been born within the territorial limits of the U.S. or, if outside those limits, born to parents who are or (if deceased) were U.S. citizens. Like U.S. presidents, astronauts employed by the National Aeronautics and Space Administration (NASA) must be U.S. citizens, but unlike presidential candidates, they can be naturalized U.S. citizens. Franklin Chang Díaz is the first naturalized American citizen to become an astronaut; he is also the first Hispanic-American astronaut and the first native Costa Rican to join the U.S. space program. When Chang Díaz arrived in the U.S. from Costa Rica, in 1967, at age 17, he came with minimal knowledge of English but with the determination to become an astronaut—an ambition that had gripped him since the dawn of the space age, in 1957, when the Soviet Union launched the first man-made satellite to orbit Earth. In the U.S. he became fluent in English, earned a bachelor's degree in mechanical engineering and a doctorate in plasma physics, and conducted scientific research at the Massachusetts Institute of Technology (MIT). During his quarter-century career as an astronaut, which began in 1981, he com-

## **Chang Díaz, Franklin**

*Apr. 5, 1950—  
Astronaut; physicist;  
rocket scientist;  
entrepreneur*

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pleted a record seven missions (only one other astronaut has flown that many); he spent a total of 1,601 hours in space, including 19 hours and 31 minutes on three spacewalks.

After his retirement from NASA, in 2005, Chang Díaz founded the Ad Astra Rocket Co., to continue his work in plasma physics and nuclear fusion. His goal is to develop a new kind of rocket engine that, he has predicted, “will revolutionize space travel, putting our entire solar system at our disposal,” in the words of an on-line Public Broadcasting System (PBS) blurb publicizing a documentary about Chang Díaz that aired on its series *Nova* on July 14, 2009. Chang Díaz told Erica Naone for *Technology Review* (September 25, 2007, on-line), “In order for us to conduct a serious space-exploration program, we need to develop two things: power and propulsion. Power in space is still severely limited. Mainly, we use solar power. This is fine as long as we stay near the sun, but . . . far and beyond, we will need to develop nuclear electric

power. If we don’t, we might as well quit. We’re not going to get anywhere without it.” He also said, “Space is a vast void, and you’re really going to have to travel fast if you’re going to have any chance of surviving. I . . . would not want to send people to Mars on a fragile and power-limited ship. If you send people that far, you have to give them a fighting chance to survive, and the only way you can do that is if you have ample supplies of power. Power is life in space.”

One of the six children of María Eugenia Díaz and Ramón A. Chang Morales, Franklin Ramón Chang Díaz was born on April 5, 1950 in San José, Costa Rica. (In some sources, including NASA Web sites, his surname is hyphenated.) His paternal grandfather immigrated to Costa Rica from Guangzhou (Canton), in southern China, and married a descendant of Spanish settlers. “I still have a large number of family members” in China, Chang Díaz told Julie D. Soo for *AsianWeek* (December 22, 2004.) His father was half-Chinese, his mother Costa Rican,

making him one-quarter Chinese. “To define me only as Hispanic is too narrow,” he told Peggy Hernandez for the *Boston Globe* (January 3, 1986). During the early years of his childhood, Chang Díaz lived with his family in Venezuela, where his father worked in the oil industry as a construction foreman. “I wanted to be just like my father,” Chang Díaz told Soo. “He taught me about a strong work ethic: to be honest and to be on time.”

Chang Díaz recalled to the astrophysicist Neil deGrasse Tyson on *Nova* that when he was “about four or five, . . . I took my sister, at 2:00 or 3:00 in the morning, and we climbed to the roof of our house. And we sat on the roof, eating grapefruits with sugar and looking at the stars.



Tony Ranze/AFP/Getty Images

## Franklin Chang Díaz

The sky was absolutely beautiful. I knew that among those stars there were other worlds, other places, and I wanted to be there.” Using cardboard boxes as spaceships, he and his young cousins would pretend to be astronauts. The news that the Soviet Union had successfully launched *Sputnik 1*—the first Earth-orbiting satellite—on October 4, 1957 made a lasting impression on him. “I can remember standing outside as a boy of 7 one night in 1957, looking up at the night sky, straining for my first glimpse of this thing they called *Sputnik*,” he told Mike Toner for the *Miami Herald* (November 15, 1983). “I decided then and there that I wanted to be an astronaut.”

As a student at the Colegio De La Salle, a private San José secondary school, Chang Díaz wrote a letter to NASA about his dream of becoming an astronaut. He was crushed to learn that all prospective astronauts had to be American citizens. “It drove me crazy,” he recalled to Joseph D’Agnese for *Discover* (November 2003). “Even today it does. Why would they encourage us to be rocket scientists if we couldn’t be? Space exploration is a worldwide endeavor, and the fact that the United States is on top doesn’t mean they should be the only ones in it.” Chang Díaz resolved to learn English and become a U.S. citizen. After his high-school graduation, in 1967, he flew to the U.S. with a one-way ticket his father had bought for him and \$50 that he had earned from a part-time job. While living with relatives in Hartford, Connecticut, he enrolled at Hartford High School. There, he became fluent in English, and when he graduated, in 1969, he ranked at the top of his class. He also won a full scholarship to the University of Connecticut. In his interview with D’Agnese, Chang Díaz said that that particular scholarship was for U.S. citizens only, but university administrators had mistakenly thought he was Puerto Rican, and they let him keep the scholarship to avoid the embarrassment that rescinding it might bring to the school.

Chang Díaz entered the University of Connecticut at Storrs a few weeks after the American astronauts Neil Armstrong, Edwin “Buzz” Aldrin Jr., and Michael Collins traveled to the moon in *Apollo 11*. The momentous voyage, during which humans first walked on the moon, “was a reaffirmation of something that at the time was kind of still elusive” for Chang Díaz, as he remarked to Wendy Pedrero for *Latino Leaders* (October 1, 2004). During his undergraduate years Chang Díaz worked as a research assistant in the university’s Physics Department. In 1973 he earned a B.S. degree in mechanical engineering. He then entered the Massachusetts Institute of Technology, in Cambridge, where his research centered on fusion technology and plasma-based rocket propulsion. “Fusion” refers to nuclear fusion, in which the nuclei of two or more atoms merge, with the release of a great deal of energy; plasma in this context is defined as ionized gas—superhot gas (with temperatures as high as 180 million degrees) whose constituent particles are negatively or positively charged and respond to electromagnetic fields. Considered a fourth state of matter, ionized gas is more common in the universe than the other three states of matter (solids, liquids, and ordinary gases); the sun, for example, is composed of plasma. Chang Díaz’s ideas about plasma-based rocket propulsion “be-

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gan as a result of my Ph.D. thesis,” he recalled to Tyson. “It was clear to me that chemical rockets, the conventional rockets that we had been using all along, were not really going to give us the capability to travel far, to Mars, to Jupiter.” According to the Ad Astra Rocket Co. Web site, his doctoral research involved “the controlling and ducting of million degree plasmas, in magnetic structures called magnetic mirrors.” Chang Díaz received an Sc.D. degree in applied plasma physics and fusion technology in 1977.

That same year Chang Díaz became a naturalized U.S. citizen and joined the Charles Stark Draper Laboratory (formerly the Instrumentation Laboratory) at MIT. During the next three years, he worked on the development of plasma and fusion technology. In 1980 Chang Díaz successfully applied to NASA’s space-shuttle program, along with only 14 others among the 3,500 applicants. As part of his training, he worked in the Shuttle Avionics Integration Laboratory (SAIL) and participated in early studies for space-station design. In August 1981 he officially earned the title of astronaut. Notice of that achievement came to him in a telephone call that he received while he was in the office of his superior at the Draper Lab. “I was so excited that I started pacing in circles and wrapped the phone cord around my superior’s neck,” he recalled to D’Agnese.

Chang Díaz served as a member of the Earth-bound support crew preparing for the first mission of Spacelab, a multi-use scientific laboratory that joined 22 flights of one or another of the space shuttles between November 1983 and April 1998. Between October 1984 and August 1985, Chang Díaz led the astronaut-support team at the Kennedy Space Center, on Cape Canaveral, near Orlando, Florida.

Chang Díaz’s first space flight—mission STS-61-C on the space shuttle *Columbia*—extended from January 12 to January 18, 1986. (“STS” is the acronym for Space Transportation System, the official name of the space-shuttle program.) STS-61-C was the 24th mission of the program and the seventh for the *Columbia*, which on that mission was piloted by Charles F. Bolden Jr. (who was named NASA’s administrator in mid-2009). During the flight Chang Díaz helped to deploy a communications satellite, performed astrophysics experiments, and operated a materials-processing device. Ten days after he and the other members of the STS-61-C crew returned to Earth, the space shuttle *Challenger* broke apart 73 seconds after liftoff, killing all seven crew members. “By luck my crew was shifted to the earlier shuttle,” Chang Díaz recalled to Soo. “It was a realization of fragility that I didn’t recognize my first time in space. The first time felt fun, indestructible. I approached my second flight with a scar. I was no longer a rookie; I had battle scars that hurt.”

On his second space mission, STS-34 (October 18–23, 1989), Chang Díaz flew aboard the space shuttle *Atlantis*. The crew on that mission deployed the satellite *Galileo*, which on December 7, 1995, after traveling 2.3 billion miles over more than six years, began orbiting the planet Jupiter. (*Galileo* continued to relay a huge amount of information about the Jovian atmosphere and surface for eight years.) Chang Díaz took part in STS-46 (July 31–August 8, 1992), an eight-day mission during

which the crew deployed the unmanned Earth-orbiting satellite European Retrievable Carrier, which was designed to conduct a dozen experiments; called EURECA, the satellite returned to Earth unharmed one year later. Also during that mission Chang Díaz and his crewmates, in a collaborative effort between NASA and the Italian Space Agency, conducted the first Tethered Satellite System test flight, in which a satellite was extended from the *Atlantis* by means of a thin Kevlar cord. Because of equipment problems, the tether extended 6.1 miles rather than the intended 12.5 miles, but it still enabled the astronauts to gather information about the electrodynamics of such a tether system.

Chang Díaz's fourth mission, STS-60 (February 3–11, 1994) was the first one in which a U.S. space shuttle (*Discovery*) rendezvoused with the Russian space station *Mir* and the first in which a Russian cosmonaut, Sergei K. Krikalev, visited an orbiting shuttle. STS-75, Chang Díaz's fifth mission, on board the *Columbia*, took close to 16 days (February 22 to March 9, 1996). It marked the third flight of the United States Microgravity Payload, an array of scientific devices that were controlled remotely from the Spacelab Mission Operations Control Center at the Marshall Space Flight Center, in Huntsville, Alabama. STS-91 (June 2–12, 1998), again on the *Discovery*, marked Chang Díaz's sixth space mission and the final one in which a U.S. shuttle docked with the Soviet *Mir*. The final space mission in which Chang Díaz participated was STS-111 (June 5–19, 2002), on the *Endeavour*. That mission took a new crew (Expedition Five) to the International Space Station (which is approximately as big as a football field) and supplied a Canadian mobile base for the space station's robotic arm. During that mission Chang Díaz performed three spacewalks to assist in the installation of the mobile base. At the end of STS-111, the *Discovery* brought to Earth the Expedition Four crew, who had spent 196 days aboard the International Space Station.

Earlier, in 1983, while a NASA employee, Chang Díaz had returned to MIT as a visiting scientist; he worked at the school's Plasma Fusion Center, where he ran the plasma propulsion program for the next 10 years. From 1993 to 2005 he directed the Advanced Space Propulsion Laboratory at the Johnson Space Center, in Houston, Texas, where he continued his work with plasma propulsion using a magnetic mirror moved there from MIT. In conducting plasma experiments Chang Díaz collaborated with scientists associated with the University of Houston, the University of Texas at Austin, Rice University, and other academic institutions.

In 2005 Chang Díaz retired from NASA and set up the Ad Astra Rocket Co., with himself as chairman and chief executive officer. That year Ad Astra and NASA signed a Space Act Agreement, which specified that, while the space agency and the company would work together, Chang Díaz's rocket technology was a private pursuit. Chang Díaz holds patents in his own name for several of the techniques and devices he has created.

Ad Astra's headquarters are in Webster, Texas, near Houston, and it also has a laboratory at EARTH University (La Escuela de Agricultura de la Región Tropical Húmeda, or School of Agriculture of the

Humid Tropical Region), in Liberia, Costa Rica. Funded by private investors, the firm is developing plasma rocket-propulsion technology, specifically the Variable Specific Impulse Magnetoplasma Rocket (VASIMR), which grew out of the research Chang Díaz began as a graduate student. The rocket uses electromagnetic waves and radio waves to heat gases such as argon and hydrogen to temperatures high enough to transform them into plasma, whose expulsion provides the rocket's thrust. Chang Díaz explained to Neil deGrasse Tyson, "Typically, a conventional rocket runs at temperatures of a few thousand degrees. Sounds pretty hot, but we would like to run at temperatures of a few million degrees, temperatures like the sun. . . . At those temperatures, the stuff that you're shooting is going so fast that you only need little, tiny amounts of it." Plasma rockets would not only be far less expensive but also far faster than conventional rockets, thus reducing significantly the estimated time of travel to destinations in space.

"The VASIMR isn't any use for getting into space in the first place as its power-to-weight ratio is small: the VX-200, the size of a small car, can only produce enough thrust to lift half a kilogramme or so off the ground," Billy Ozks wrote for *TheTechJournal.com* (April 29, 2011). "Once in orbit, however, a VASIMR comes into its own. A normal rocket will burn up any practical amount of fuel very quickly: thus it can be used only in brief bursts. A spacecraft driven by such means must spend almost all its time coasting along unpowered. Thus a journey to Mars, for instance, would take 6 months for a conventional spacecraft. A VASIMR, however, can keep on exerting its relatively tiny push for weeks on end without using any more juice, gradually boosting a ship up to terrific speeds that would never be possible with a chemical rocket."

In the near future VASIMR rockets might be used for in-space refueling and repair, for removing space trash (commercially owned inoperative satellites) from Earth's orbit, and for transporting cargo to the moon and robots into deep space. In 2009 Ad Astra successfully tested the VX-200, a small-scale prototype of the VASIMR engine, in a vacuum chamber at NASA facilities. NASA and Ad Astra hope to substitute Ad Astra engines for the fuel-hungry device that currently provides thrust for the International Space Station and the massive solar arrays that generate its electricity.

According to his biography on the NASA Web site, Chang Díaz was "instrumental in implementing closer ties between the astronaut corps and the scientific community," through the Astronaut Science Colloquium Program, which he formed in 1987, and the Astronaut Science Support Group, which he directed for several years. He has organized conferences in several Central and South American countries to promote the possibilities for space-related industries there. On two of his space-shuttle missions, he conducted experiments aimed at identifying "potential natural inhibitors to Chagas disease in the microgravity of space," according to the Ad Astra Web site. For two years he managed a residence for formerly institutionalized mental patients, and he has also served as an instructor at a drug rehabilitation program for Hispanic-Americans in Massachusetts. He helped to draft and implement

SUGGESTED READING:

adastrarocket.com

*AsianWeek* p8 Dec. 22, 2004

*Discover* (on-line) Nov. 8, 2003

jsc.nasa.gov

*Latino Leaders* p22 Oct. 1, 2004

*Miami Herald* B p1 Nov. 15, 1983

pbs.org July 14, 2009

*TheTechJournal.com* Apr. 29, 2011

“The Strategy for the 21st Century,” described on the Ad Astra Web site as “a master plan designed to transform Costa Rica into a fully developed country before 2050.” Since 1993 he has taught as an adjunct professor in the Physics Departments of both the University of Houston and Rice University, also in Houston.

Chang Díaz’s honors include, from NASA, two Distinguished Service Medals (1995, 1997) and three Exceptional Service Medals (1988, 1990, 1993), four honorary doctoral degrees, and a Medal of Excellence from the Congressional Hispanic Caucus (1987). From his first marriage, to Canoce Buker, which ended in divorce, Chang Díaz has two daughters: Jean Elizabeth Chang Díaz, a teacher, and Sonia Chang Díaz, the first Latina to win election to the Massachusetts state Senate, in 2008. With his second wife, identified variously as the former Peggy Marguerite Doncaster or Peggy Marguerite Stafford, he has two daughters, Lidia Aurora and Miranda Karina. In Costa Rica, where he is considered a hero, his image has appeared on a postage stamp. His recreational interests include playing soccer, scuba diving, hiking, and flying gliders. His book *Los Primeros Años: Mis Primeros Aventuras en el Planeta Tierra* (“The First Years: My First Adventures on Planet Earth”), the first in a planned autobiographical trilogy, covers his life until he left Costa Rica for the U.S. “I always tell the kids I meet to follow your dreams; it’s the first thing I tell them, to not let anyone tell you that you can’t do something, until you find out for yourself,” he told Tyson. “I’m talking about the ability of a child to say, ‘Look, I want to change the world.’ Go do it.”

—W.D.

The photographer Bill Cunningham has been documenting fashion—what people wear day to day—in New York City since the 1960s. His subjects are ordinary New Yorkers and visitors to the city as well as celebrities and other newsmakers, but only people whose apparel strikes him as fascinating or beautiful. To the general public Cunningham is best known as the man behind the “On the Street” and “Evening Hours” columns, which have appeared in the Style section of the Sunday *New York Times* every week since the early 1990s. For “On the Street” Cunningham—whose primary means of transportation and frequent perch is his bicycle—occasionally takes photos in Central Park, Madison Square Park, Governors Island, Union Square, and, during Fashion Week, all over Midtown Manhattan; but his usual location, where he often spends hours a day, is the intersection of Fifth Avenue and 57th Street. Cunningham “seeks out and captures humanity amid the maelstrom of life . . .,” Carina Chocano wrote for the *New York Times* (March 15, 2011). “In these fleeting and otherwise unseen or unremarked moments, Mr. Cunningham finds something creative, life-affirming and free, and preserves it forever.” “He’ll do anything for the shot,” Kim Hastreiter, the co-founder and co-editor of *Paper* magazine, told Richard Press, whose documentary about the photographer’s life and work, *Bill Cunningham New York*, premiered in 2011. “I’ve been in deep conversations with him where he’ll just run from me because

## Cunningham, Bill

Mar. 13, 1929–  
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