Curriculum Vitae

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Research Interests: High Energy Astrophysics and Gamma Ray Astronomy; Gamma-Ray Bursts; Blazars and Active Galactic Nuclei; Positron Astrophysics; Solar Flares Physics; Neutron Stars and Black Holes; Starburst Galaxies and Clusters; Cosmic Rays/Ultra-High Energy Cosmic Rays

Present Position: Astrophysicist; PI of Space Radiations Section of the High Energy Space Environment Branch in the Space Science Division of the Naval Research Laboratory

Previous Positions: 1991-1992, Research Scientist, Department of Space Physics and Astronomy, Rice University, Houston, TX.
1990, Research Physicist, Berkeley Space Sciences Laboratory.
1987-89, Postdoctoral Research Physicist, Lawrence Livermore National Laboratory.
1986, Postdoctoral Research Associate, University of Maryland.
1984-86, National Academy of Sciences/National Research Council Postdoctoral Research Associate, Goddard Space Flight Center, Greenbelt, Maryland.

Education: Ph.D., 1984, University of California, San Diego, Physics, supervisor: Robert J. Gould
M.S., 1980, University of California, San Diego, Physics.
M.A., 1979, Dartmouth College, Hanover, New Hampshire, Physics.
B.S., 1977, Harvey Mudd College, Claremont, California, Physics.

Professional Society Memberships: American Physical Society, American Astronomical Society, International Astronomical Union

Committees: Science Organizing Committee of the Second Fermi Symposium, Rome, Italy, May 2011
Saas-Fee Lecturer, Les Diablerets, Switzerland, 15 – 20 March, 2010
Affiliate Professor, Physics and Astronomy Department, George Mason University, Aug 2009 -
SOC of the First Fermi Symposium, Washington, DC, Nov. 2 – 5, 2009
NASA Chandra Guest Investigator Program, 2006
Visiting Professor at the Intern. La Plata School in Astrophysics, La Plata, Argentina, 2008 March
Full GLAST/Fermi Collaboration Member, > 2007
Advanced Compton Telescope Science Working Group, 2005 –
NASA Senior Review, 2006
Councilor, Division of Astrophysics (DAP) of the American Physical Society (APS), 2006-2009
VERITAS External Oversight Committee, 2003-2009
NASA Structure and Evolution of the Universe Subcommittee, 2001-2004
Chair, DAP/APS, 1999-2003

NASA South Carolina EPSCOR Review, 2003

International Gamma-ray Astronomy Laboratory (INTEGRAL) Time Allocation Committee, 2001, 2003

DAP Program Chair for the April 2001 Washington, DC APS Meeting

High Energy Neutrino Astrophysics Panel of the Particle and Nuclear Astrophysics and Gravitation International Committee of the International Union of Pure and Applied Physics, 2000-2002

Gamma-ray Large Area Space Telescope (GLAST) Science Working Group and GLAST Interdisciplinary Scientist, 2000-2009

GLAST Facility Science Team, 1999

NASA Astrophysical Theory Program Review, 1999

Executive Committee Member, High Energy Astrophysics Division, American Astronomical Society, 1995-1997

Executive Committee Member-at-Large, DAP/APS (1996-1998)

NASA Long Term Space Astrophysics Program Review: 1991, 1994

Scientific Organizing Committee of the Fourth Compton Symposium, Williamsburg, VA, 28-30 April 1997

Scientific Organizing Committee of the Workshop on the TeV Astrophysics of Extragalactic Sources, 23-24 October, 1998, in Cambridge, Massachusetts.

NASA ASCA Guest Investigator Program Review: 1995

Scientific Organizing Committee of the Meeting of the High Energy Astrophysics Division of the American Astronomical Society, San Diego, CA, 29 April - 4 May 1996

NASA Astrophysics Data Program Review: 1996

NASA Compton Gamma-Ray Observatory Guest Investigator Program Review: 1993, 1994, 1995 (panel chair), 1998

Graduate Students: Steven J. Sturner, Rice University, Ph.D. 1993; Hui Li, Rice University, Ph.D. 1995

Scientific Advisory: NRL/NRC Postdoctoral Research Associateships Program. Research Associates:

Dr. Justin Finke, Dr. Soebur Razzaque

Dr. Jeffrey G. Skibo, Dr. Steven J. Sturner, Dr. James Chiang, Dr. Stuart D. Wick, Dr. Truong Le.

German Academic Exchange Service: Dr. Markus Böttcher.

American Society for Engineering Education (ASEE) Postdoctoral Fellowship Program: Dr. Robert Berrington. ASEE Summer Faculty Research Program: Professor Stanley P. Davis (Lincoln University), Professor Mayer Humi (Worcester Polytechnic University), Professor Govind Menon (Troy University).

Thomas Jefferson High School for Science and Technology Mentorship and the DoD Science and Engineering Apprenticeship Program: Mr. Kurt E. Mitman, Mr. Jeremy M. Holmes

Books: *Proceedings of the Fourth Compton Symposium*, eds. C. D. Dermer, M. S. Strickman, and J. D. Kurfess (New York: AIP), 1997.
Part 1: The Compton Observatory in Review;
Part 2: Papers and Presentations

High Energy Radiation from Black Holes, by Charles D. Dermer and Govind Menon
Princeton University Press, Nov. 2009, 512 pp.

Honors: Fellow of the American Physical Society, 1999
NASA Group Achievement Award to Large Area Telescope Team, 2008
Alan Berman Research Publication Award, NRL, 2009

June 2010

Brief Description of Research Activities of Dr. Charles D. Dermer

Dr. Dermer has made fundamental contributions to particle astrophysics and γ-ray astronomy in theory and modeling by treating basic physical processes involving high-energy interactions between particles and photons in magnetized plasma. With these studies in hand, he and his colleagues develop numerical simulation models to reproduce the spectral energy distributions (SEDs) of high-energy radiation sources using understood and generally accepted physical principles. The most energetic astrophysical γ-ray sources are also the most variable, and patterns in the changing SEDs contain important information. Dr. Dermer tries to fit this data using physical mechanisms that give information about the nature of the sources, such as particle acceleration at shocks, energy loss and radiation by particles, jet formation by black holes, and transport of cosmic rays from their acceleration sites.

The field of gamma-ray astronomy is enjoying a surge of new results with the launch of Fermi. In fact, this is a period of amazing growth in the entire field of high-energy astronomy and particle astrophysics, considering that the South Pole IceCube Neutrino Experiment has reaches its design sensitivity next austral summer, the Pierre Auger Observatory of ultra-high energy cosmic rays has had two major data releases, and the Swift GRB satellite and ground-based γ-ray telescopes sensitive to TeV (10^{12} eV) photons are actively scanning the skies for γ-ray transients. Dermer and Menon wrote a book containing a detailed description of the astrophysics helpful for solving problems arising in high-energy black-hole astrophysics and cosmic-ray astronomy. With the flood of new results coming in from a multitude of observatories, Dr. Dermer is poised to make new discoveries in collaboration with the Fermi Team, his NRL group, and international partners.

In preparation for this active period in high-energy astrophysics, several numerical simulation tools were developed and implemented by Dr. Dermer in anticipation of major results made with Fermi. Of note, and to be described more fully below, is the (1.) `COSMO` numerical simulation program, a secondary nuclear production model for proton-proton and proton-ion collisions giving accurate secondary energy spectra of baryons, leptons, and photons in proton-proton collisions from threshold to the highest energies. This code, stemming originally from Dr. Dermer's thesis work (#8,9), finds applications in the interpretation of data from Solar flares, supernovae, the Milky Way, clusters of galaxies, and the Earth's atmospheric γ-ray glow. Other major accomplishments include (2.) a relativistic jet model, where the accelerated particles in the jet scatter ambient radiation in the environment of the massive central black hole, that also calculates high-energy neutrino and γ-ray production made through photo-hadronic interactions of energetic protons and ions in jet sources; (3.) studies in the theory of cosmic-ray origin at $\sim$GeV–PeV (10^9–10^{15} eV) and >EeV (10^{18} eV) energies, and (4.) a new research initiative to calculate the background light from stars, galaxies, and black holes.

The capabilities of the Space Radiations Section led by Dr. Dermer are broader still, encompassing a major spallation interaction code for the production of γ-ray lines from the decay of excited nuclei made in the collisions or protons, α particles, and ions; a Monte Carlo program to calculate the Compton-scattered spectra of photons as they pass through a hot or even mildly relativistic thermal plasma with temperature gradients; and finite differencing and Monte Carlo simulation programs to model the spectral energy distributions of sources of MeV and GeV radiation formed by magnetized plasma moving towards us almost at the speed of light.

As new observations with Fermi are made, analysis tools that Dr. Dermer and his colleagues have developed are being employed to explain unusual events in the sky, such as gamma-ray bursts so bright and distant that they apparently emit more energy than all the universe for a few seconds, or the SEDs of blazars, which are supermassive black holes with masses typically of $\approx 10^9$ Solar masses, that eject highly energetic plasma jets that are aligned, by chance, in our direction. These techniques and tools have been developed over nearly a quarter century, and have reached fruition due to sustained superior performance by Dr. Dermer over this period, which has culminated with the launch and success of the Fermi Gamma ray Space Telescope.

Fundamental Particle and Nuclear Interactions

Some of Dr. Dermer's most important contributions in physics have been fundamental studies of particle-collision processes in high-energy astrophysics. One of the most elementary particle processes, which at the same time is of primary importance in γ-ray astronomy, is the interaction between a high-energy proton and a proton at rest. Above the pion production threshold at ≈ 100 MeV, secondaries are formed and decay to make γ rays and energetic electrons and positrons. The γ-ray secondaries, and those made by the electrons and positrons, form the diffuse γ-ray glow of the Milky Way galaxy. At least this is what was claimed in 1972, at the time of the report of the discovery of 621 γ-ray events towards the plane of the Milky Way.

By the time of Dr. Dermer's thesis, in 1984, it was generally accepted that cosmic rays make the Galactic γ-ray glow, but methods to calculate the γ-ray spectrum were in dispute. Dr. Dermer resolved this controversy by proposing to use scaling representations at energies well above threshold, as originally suggested by Richard Feynman, and calculations of baryon resonance excitations, particularly the Δ^+ resonance, for interactions near threshold. The transition between the low-energy exclusive treatment to the high-energy inclusive treatments was based on a detailed comparison of the predictions of the particle physics models with experimental cross sections in the GeV regime. The two papers (#8,9) by Dr. Dermer outlining this method have received 201 and 94 citations, respectively.

The `COSMO` code sprang from the need to calculate the diffuse glow of the γ-ray light made by cosmic-ray interactions with gas and dust in the plane of the Milky Way, and was used in the EGRET days to calculate γ-ray production from the supernova remnants of exploding stars (#73). But it had an earlier use to model the unexpected γ-ray emission recently detected above 100 MeV from Solar flares with the Solar Maximum Mission in the mid-1980s. This motivated the creation of a detailed Solar flare code using pion-production that is found in a paper (#10, with 124 citations) by Dr. Dermer, with Dr. Reuven Ramaty and Ronald J. Murphy (both then at the NASA Goddard Space Flight Center), that has become a standard reference for Solar γ-ray emisison.

Since then, the `COSMO` code has been upgraded to calculate secondary production spectra of electrons, positrons, γ rays and neutrinos. A detailed paper (#108) reporting calculations of the γ-ray emission from shocks formed in merging clusters of galaxies with the `COSMO` code made by Dr. Dermer in association with Dr. Robert Berrington, then an NRC postdoctoral associate with Dr. Dermer, earned over 50 citations, even though γ-ray emission has not been discovered—even with Fermi—from clusters of galaxies.

The `COSMO` code is now being adapted to model Fermi observations of the γ-ray glow of the Milky Way and the spectral maps of supernova remnants over wide energy ranges. The new capability being built into this code is to follow particles while they lose energy and diffuse away from the acceleration region. The first maps of supernova remnants at GeV energies made with data from Fermi were just reported, and the first TeV maps of supernova remnants and Galactic γ-ray sources date back only to 2006. Analysis and modeling of the γ-ray data with the `COSMO` code presents Dr. Dermer and his group the best chance to establish the sources of cosmic rays using the new information from Fermi.

Relativistic Jet Physics

Prior to the launch of the Compton Gamma Ray Observatory (CGRO) in 1991, there was only one extragalactic source of high-energy γ rays known, the quasar 3C 273. This object, which was one of the first sources discovered at high redshifts by Professor Maarten Schmidt of the California Institute of Technology, exhibits bright UV radiation thought to be made by matter accreting onto a supermassive black hole. But being radio-luminous, 3C 273 also has outflowing plasma jets characteristic of radio galaxies. There was great uncertainty about the origin or reality of the high-energy radiation until the Energetic Gamma Ray Experiment Telescope (EGRET) on CGRO spotted a γ-ray bright source, 3C279, near 3C 273, but did not detect 3C 273 itself until later in the CGRO mission.

Like 3C 273, 3C 279 is also radio-loud and a radio jet source. Shortly after the announcement of this discovery by the EGRET team, Dr. Dermer and his colleagues Dr. Reinhard Schlickeiser (Max-Planck-Institut für Radioastonomie in Bonn; now professor at Bochum University, Germany) and Dr. Apostolos Mastichiadis (Max-Planck-Insitut für Kernphysik in Heidelberg; now professor at the University of Athens) proposed in 1991 that the γ rays from 3C 279 were made by radio-emitting electrons that scatter photons from outside the jet. This so-called external Compton scattering model has become the standard explanation for the origin of γ-rays, and makes predictions for multitude of effects, including correlations between the radio and γ rays and different beaming factors of the various radiations, an effect discovered (#50) by Dr. Dermer. These factors are required to perform accurate studies of the statistics of γ-ray emitting galaxies, which reveal black-hole growth, fueling, and dimming. The paper (#30) by Drs. Dermer, Schlickeiser, and Mastichiadis proposing external Compton scattering process has received 272 citations and a more detailed paper (#36) exploring the physics of this mechanism has received 337 citations. The paper by Dr. Dermer on beaming factors has received more than 120 citations.

Relativistic jet physics for blazar galaxies that exhibit strong, variable, and highly polarized radio, optical, and γ radiation is an important subject in high-energy astronomy More than 600 such blazars have been detected with Fermi in data from its first eleven months (#197), which is a factor 10× more blazars than known in the EGRET/CGRO days. Dr. Dermer has helped write numerous active galaxy papers with the Fermi team and, in collaboration with Dr. Justin Finke of NRL, has developed state-of-the-art modeling codes that are integral to the analysis of γ-ray and multiwavelength emission from blazars and radio galaxies. The unusual SEDs and rapid variability, at times showing strong flux variations in less than a few hours, point to a black-hole engine. The codes developed to reproduce the SEDs of blazars imply the magnetic field and the speed of the emitting plasma and the power of the jet, from which important restrictions on the energy source of black-hole jets can be made. The reservoir of spin energy carried by the black hole adds to the accretion power from the dark star.

Over the last 12 years, Dr. Dermer in collaboration with Dr. Markus Böttcher (now professor at Ohio University) have been considering cosmic-ray hadron as well as electron-type models. Dermer and Böttcher made the first detailed calculations of neutrinos from GRBs, with the accompanying γ-ray flux. With IceCube and Fermi, we are in a position to test these predictions. In more detailed calculations with Dr. Armen Atoyan (Université de Montréal, now professor at Concordia University) published in Physical Review

Letters (#99,107), neutrino production from blazars was found to depend strongly on the scattered radiation made in the environments of luminous black holes, or the supernova remnant shell emissions in some models of GRBs. The idea that black-hole blazar and GRB jets are beam sources of neutral particles, including neutrons, neutrinos, and γ photons, is worked out in a series of papers (#105,125) by Atoyan and Dermer.

Black-hole Physics and Astrophysics

Energy physics is even important for black holes, which have in principle three energy reservoirs. Black holes, if very light ($\sim 10^{18}$ gm), can evaporate by Hawking radiation, for which there is yet no evidence. Matter can fall onto black holes and in the accretion process heat up to X-ray temperatures. And energy can be extracted from that contained in the black-hole rotation. The latter process is dealt with in the book by Dr. Dermer and Professor Menon.

Building on the ideas by Penrose, Blandford and Znajek, Professor Govind Menon, while visiting NRL as a summer faculty in 2005, worked with Dr. Dermer to solve the constraint equation for a force free-magnetic field around a rotating black hole. Their solution (#121,132) generalizes the Blandford/Znajek split monopole solution to all values of a, the spin parameter of the black hole. The jet problem is not yet solved, as this solution has the largest energy flux along the equator.

In other black-hole research, Dr. Dermer and colleagues have used the observed statistical and spectral properties of black-hole events to model evolution of blazar black holes (#100) and the rates of black-hole formation (as revealed by GRBs) (#130) through cosmic time. This probes the question whether black-hole spin triggers jet formation. This line of enquiry also tries to explain the stark differences between radio-loud black holes with extended radio jets, which can also be exceedingly γ-ray loud, and radio-quiet black holes, though with bright UV emission are never seen in GeV γ rays (#51). The source of the energy, assumed to be from black holes, of the γ rays and ultra-high energy cosmic rays, is one of the themes of the book "High Energy Radiation from Black Holes."

Cosmic-Ray Origin Studies

One of the great unsolved problems in astronomy and physics is the origin of the cosmic rays, ultra-relativistic charged particles diffusing throughout the Milky Way and into our Solar cavity, which were discovered in 1912 by Victor Hess, for which he won the 1936 Nobel Prize. There are other parts to this story, however. According to Dr. Dermer, one concern is from cosmic rays impacting spacecraft and making event upsets in computers or defects in materials, and another is cosmic rays making radiation effects on humans not shielded artificially or by the Earth's magnetosphere or atmosphere. A third concern is cosmic-ray flux increases due to nearby supernovae or GRBs that took place earlier in the Galaxy.

The intensity of the cosmic rays, as is well known, is modulated by the strength and activity of the Sun and its outgoing solar wind, so that the intensity of cosmic rays near 1 GeV correlates inversely with 11-yr sunspot (half the solar) cycle. As recently proposed by Dr. Dermer, because the intensity of $\sim$ GeV cosmic rays are lower interstellar medium by an uncertain amount from the measured cosmic-ray flux in the near-Earth space environment, γ-ray measurements through the plane of the Galaxy can reveal the low-energy part of the cosmic ray spectrum. Remarkably, the underlying assumption that the cosmic-ray spectrum throughout the Galaxy is the same as measured locally, seems to be true (#167,175).

But this does not tell from where cosmic rays originate, which is the root science question. It is generally believed that they are accelerated at the shocks in the remnants of supernova explosions, and this seems to be what the Fermi and ground-based γ-ray telescope data are showing. But supernova remnants are not all the same: the young, ~ 3000 yrs, are TeV bright, and the middle-aged, $\sim 30,000$ yrs are GeV bright (#168,187,191). Drs. Dermer and Finke are now applying the `COSMO` code to try to model the evolution from a lepton-dominated young remnant to a proton dominated middle-aged remnant.

Of equal or more fascinating interest is the problem of the origin of the ultra-high energy cosmic rays, which are so energetic that a single nucleus contains macroscopic Joules of energy. Since they are also rare, they represent a slight addition to the particle energy flux we measure. Not being contained by the Milky Way's magnetic field, they are certainly of extragalactic origin. Probing outside the Galaxy, we can look for sources by tracing back the arrival directions of the highest energy cosmic rays to their sources. But the original claim for ultra-high energy clustering has been weakened with the addition of new data from the Pierre Auger collaboration. As theorists, Dr. Dermer and Prof. Menon postulate in their book that only jetted black-hole engines have the conditions favorable to accelerate particles to the highest energies, and those are found in two classes of objects: the highly relativistic jets of GRBs made while forming a Solar-mass black hole, and the persistent and intermittent plasma flows of blazars with supermassive, $\approx 10^9$ Solar-mass black holes. Other scenarios would conflict with these claims, such as those where the highest energy cosmic rays are accelerated by young, highly magnetized neutron-star models or formed as secondaries in the decay of exotic particles. With the large number of experiments in operation, these ideas will be tested, and the solution to the problem of cosmic-ray origin may soon be answered.

Modeling the Background Light

Even before Olbers thought deeply about it, people have surely asked whether the nighttime sky glows, as it does in the plane of the Milky Way, because of the summed emissions from many unseen faint objects. Olbers himself asked if space is infinite, why is the sky not infinitely bright?

We know that time isn't infinite, and that we live in an accelerating flat universe with cosmological dark energy making $\approx 73\%$ of the energy density of the universe, with the remaining $\approx 27\%$ composed of matter, of which only $\approx 3\%$ is normal matter that we "understand." This 3% makes the infrared, optical, X-ray, and γ-ray background radiation that functions as an inescapable cosmic glow. The major part of the radiation background, in terms of energy density, is the cosmic microwave background, which is the thermal remnant of the universe's hot early phase on which is encoded acoustic messages about its formation. At infrared and shorter wavelengths, stellar emissions over the age of the universe make the dominant contribution to the background glow. By summing up the light of stars during their lifetimes, and taking into account dust absorption and re-radiation, Dr. Dermer, with Dr. Justin Finke and postdoctoral associate Dr. Soebur Razzaque, recently made predictions (#147,190) about the intensity of infrared and optical radiation background. The level of the background optical light can be tested using γ-ray observations from sources so distant that their multi-GeV radiation is attenuated by electron-positron pair-forming collisions with the optical photons. This $\gamma\gamma \rightarrow e^+e^-$ process also allows Dermer and his colleagues to infer the intensity of the infrared radiation from low-redshift TeV blazars.

While the latest analysis, as part of a Fermi team paper, is in the refereeing stage, of related interest is the explanation for the MeV – GeV – TeV background radiation intensity. Prior to Fermi, it was generally thought that blazar emissions would make the dominant part of the γ-ray background. Dr. Dermer made calculations (#129) using a physical jet model for the EGRET blazar data that was published in the year prior to the GLAST launch, and found that the total blazar emission would only amount to $\approx 20\%$ of the claimed EGRET background. The lower flux of the diffuse extragalactic γ-ray background measured in the important paper (#194) by the Fermi collaboration roughly confirms the analysis by Dr. Dermer, and leaves open a large number of possible ways to make the γ-ray emission not explained by blazars. This measurement of the background γ-ray light with Fermi has attracted explanations in terms of dark matter annihilation, emission from structure formation shocks, and from γ-rays emitted from the radio lobes of radio galaxies¿ Dr. Dermer thinks that the the summed glow of the dim multitude of star-forming galaxies like our Milky Way is the likely explanation, and participated on the Fermi Large Area Telescope (LAT) discovery (#182) of weak GeV emission from the starburst galaxies M82 and NGC 253, which are making stars at a rate $\approx 10\times$ greater than that of the Milky Way.

Summary

In the course of developing analytical and simulation tools described above, many new and interesting physical effects have been discovered in research led by Dr. Dermer. For example, Dr. Dermer, working with Dr. Armen Atoyan, found that cooling effects due the onset of the Klein-Nishina decline in Compton scattering make a hardening of the radiating electron spectrum that can be detected as a hardening in the radio/X-ray spectrum of radio galaxies. The paper (#102) reporting this effect has received over 50 citations and has been applied to explain the hardening in the cosmic-ray electron spectrum measured with Fermi, a paper (#149) by Dr. Dermer and the Fermi Collaboration that has already received over 300 citations since being published last year. Several others were mentioned in the text above.

Dr. Dermer maintains an active research schedule, and gives many presentations, seminars, and colloquia each year. In March 2010, Dr. Dermer was one of 3 lecturers at the annual Saas-Fee school in Switzerland, where he presented 9 lectures on the Fermi Gamma ray Space Telescope results. The write-up of this lecture series will appear as one of three chapters in a book devoted to this school on "Astrophysics at High Energies." Two years earlier he was a visiting professor at the La Plata, Argentina, International School on Astronomy and Geophysics, where he delivered 5 lectures on gamma-ray bursts, with notes to the lectures published by the Asociación Argentina de Astronomía. While at NRL, Dr. Dermer has supervised 9 postdoctoral research associates, 2 DoD SEAP students, a college student, and 3 ASEE summer faculty researchers, while hosting numerous visitors. He has participated in numerous NASA review panels, NSF proposal evaluations, external review committees, and scientific organizing committees.

Charles D. Dermer: Refereed Publications

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2. Free, J. U., Dermer, C. D., Pipes, P. B. 1979. Temperature derivative of the electronic work function of copper at low temperatures. Physical Review B 19, 631-633.
3. Dermer, C. D. 1984. The production spectrum of a relativistic Maxwell-Boltzmann gas. The Astrophysical Journal 280, 328-333.
4. Dermer, C. D. 1985. Binary collision rates of relativistic thermal plasmas. I Theoretical framework. The Astrophysical Journal 295, 28-37.
5. Ramaty, R., Dermer, C. D., Murphy, R. J. 1986. Pion-decay radiation and two-phase acceleration in the June 3, 1982 solar flare. Advances in Space Research 6, 119-122.
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20. Dermer, C. D. 1989. Compton scattering in strong magnetic fields and the paucity of X-rays in gamma-ray burst spectra. The Astrophysical Journal 347, L13-L16.
21. Dermer, C. D. 1989. Thermal Comptonization Models for Gamma-Ray Emission from Black-Hole Sources. Annals of the New York Academy of Sciences 571, 513-521.

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Online Documentation

For more information about Dr. Dermer, including publication and citation listings, see
heseweb.nrl.navy.mil/gamma/∼dermer/personnel/dermer.htm

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