

# Dual dynamically tunable terahertz graphene-based plasmonic induced transparency and slow light effects

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## Abstract

A novel single-layer graphene-based structure is designed in this article. This structure consists of two graphene strips and two graphene blocks. The components of this structure generate two bright modes and one dark mode in the terahertz region, and these three modes undergo destructive interference, leading to the phenomenon of double plasmonic induced transparency. The graphene of this structure has continuity, and the Fermi level can be adjusted by adjusting the bias voltage applied to the structure. Compared with those discontinuous structures, it is easier to achieve tuning function. The structure uses the finite-difference time-domain for data simulation, uses the coupled mode theory for theoretic calculation, and compares the transmission spectra obtained by the two methods. Through observation, it can be found that the frequency positions of the peaks and dips of the simulated transmission spectrum increase with the increase of the Fermi level, showing a perfect linear relationship, which indicates that this structure has great prospects in the modulator. In addition, the structure has achieved good results in the slow light effect, and after measurement, the peak values of group index and group delay can reach up to 380 and 0.241 ps, respectively. By utilizing these advantages, this structure can provide more possibilities for the development and research of slow light fields.

**Keywords:** plasmonics, metamaterials, integrated optics devices

## 1. Introduction

In recent years, with the increasing attention and understanding of researchers on metamaterial, graphene has entered the vision of researchers [1–4]. Graphene has the advantages of high electrical conductivity, long lifetime plasmon excitation, low loss, and easy modulation [5, 6], thus is widely used in optics [7–10], materials science [11–13], micro/nano processing [14, 15], energy [16] and other fields. With the

deepening of research, scientists have found that single-layer graphene exhibits similar properties to metals in the terahertz band, and can successfully excite surface plasmons polaritons. Graphene-based metasurfaces can also achieve plasmonic induced transparency (PIT) phenomena. The traditional electromagnetic induced transparency (EIT) [17] effect is a typical quantum coherent effect, which essentially prevents atoms at the atomic level from participating in the coupling of light under the action of the coupling field, thereby gradually reducing the absorption of weak probe light by the medium and even making it completely transparent. And PIT is a phenomenon similar to EIT that occurs at the resonant frequency

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# Slow Transparency

**Edward John Wall**



## **Slow Transparency:**

**Slow Light** Jacob B. Khurgin, Rodney S. Tucker, 2018-10-08 One of the Top Selling Physics Books according to YBP Library Services The exotic effects of slow light have been widely observed in the laboratory However current literature fails to explore the wider field of slow light in photonic structures and optical fibers Reflecting recent research *Slow Light Science and Applications* presents a comprehensive introduction to slow light and its potential applications including storage switching DOD applications and nonlinear optics The book covers fundamentals of slow light in various media including atomic media semiconductors fibers and photonic structures Leading authorities in such diverse fields as atomic vapor spectroscopy fiber amplifiers and integrated optics provide an interdisciplinary perspective They uncover potential applications in both linear and nonlinear optics While it is impossible to account for all the captivating developments that have occurred in the last few years this book provides an exceptional survey of the current state of the slow light field

**New Horizon of Plasmonics and Metamaterials** Masafumi Kimata, Shinpei Ogawa, 2020-06-25 Plasmonics and metamaterials are growing fields that consistently produce new technologies for controlling electromagnetic waves Many important advances in both fundamental knowledge and practical applications have been achieved in conjunction with a wide range of materials structures and wavelengths from the ultraviolet to the microwave regions of the spectrum In addition to this remarkable progress across many different fields much of this research shares many of the same underlying principles and therefore significant synergy is expected This Special Issue introduces the recent advances in plasmonics and metamaterials and discusses various applications while addressing a wide range of topics in order to explore the new horizons emerging for such research **Western Camera Notes**, 1901 *Photonics* Léonard Dobrzyński, Yabin

Jin, Abdellatif Akjouj, El Houssaine El Boudouti, Gaetan Leveque, Housni Al-Wahsh, Yan Pennec, Cecile Ghouila-Houri, Abdelkrim Talbi, Bahram Djafari-Rouhani, 2020-11-28 *Photonics* a volume in the Interface Transmission Tutorial Book series describes the science of photonic transmission properties of the interfaces of composite materials systems and devices The book's authors review the general analysis methods of interface transmission give many examples and apply these methods to photonic applications Applications discussed include photonic crystals materials devices and circuits Offers a unique approach on photonics from the interfacial transmission point of view Reviews the interface transmission properties of composite materials for photonics applications Authored by world leading experts on interface transmission

**Well Oiled** Alex Vines, Human Rights Watch (Organization), 2009 This 102 page report details how the dictatorship under President Teodoro Obiang Nguema Mbasogo has used an oil boom to entrench and enrich itself further at the expense of the country's people Since oil was discovered there in the early 1990s Equatorial Guinea's gross domestic product GDP has increased more than 5 000 percent and the country has become the fourth largest oil producer in sub Saharan Africa At the same time living standards for the country's 500 000 people have not substantially improved Publisher description *Relationship* Randy M.

Clendenin, Martha W. *Homme*, 2002-07      *Pictorial Photography* Paul Anderson, 1917      **The American Stationer**, 1889

**Practical Color Photography** Edward John Wall, 1922      **Freedom in the World 2019** Freedom House, 2020-01-25

Freedom in the World the Freedom House flagship survey whose findings have been published annually since 1972 is the standard setting comparative assessment of global political rights and civil liberties The survey ratings and narrative reports on 195 countries and fifteen territories are used by policymakers the media international corporations civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide The Freedom in the World political rights and civil liberties ratings are determined through a multi layered process of research and evaluation by a team of regional analysts and eminent scholars The analysts used a broad range of sources of information including foreign and domestic news reports academic studies nongovernmental organizations think tanks individual professional contacts and visits to the region in conducting their research The methodology of the survey is derived in large measure from the Universal Declaration of Human Rights and these standards are applied to all countries and territories irrespective of geographical location ethnic or religious composition or level of economic development      **Freedom in the**

**World 2018** Freedom House, 2019-01-31 Freedom in the World the Freedom House flagship survey whose findings have been published annually since 1972 is the standard setting comparative assessment of global political rights and civil liberties The survey ratings and narrative reports on 195 countries and fifteen territories are used by policymakers the media international corporations civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide The Freedom in the World political rights and civil liberties ratings are determined through a multi layered process of research and evaluation by a team of regional analysts and eminent scholars The analysts used a broad range of sources of information including foreign and domestic news reports academic studies nongovernmental organizations think tanks individual professional contacts and visits to the region in conducting their research The methodology of the survey is derived in large measure from the Universal Declaration of Human Rights and these standards are applied to all countries and territories irrespective of geographical location ethnic or religious composition or level of economic development

**International Anti-Corruption Norms** Cecily Rose, 2015-08-13 This book traces the creation of international anti corruption norms by states and other actors through four markedly different institutions the Organisation for Economic Co operation and Development the United Nations the Extractive Industries Transparency Initiative and the Financial Action Task Force Each of these institutions oversees an international instrument that requires states to combat corruption Yet only the United Nations oversees anti corruption norms that take the sole form of a binding multilateral treaty The OECD has by contrast fostered the development of the binding 1997 OECD Anti Bribery Convention as well as non binding recommendations and guidance associated with treaty itself In addition the revenue transparency and anti money laundering norms developed through the Extractive Industries Transparency Initiative and the

Financial Action Task Force respectively take the form of non binding instruments that have no relationship with multilateral treaties The creation of international anti corruption norms through non binding instruments and informal institutions has the potential to privilege the interests of powerful states in ways that raise questions about the normative legitimacy of these institutions and the instruments they produce At the same time the anti corruption instruments created under the auspices of these institutions also show that non binding instruments and informal institutions carry significant advantages The non binding instruments in the anti corruption field have demonstrated a capacity to influence domestic legal systems that is comparable to if not greater than that of binding treaties With corruption and money laundering at the forefront of political debate International Anti Corruption Norms provides timely expertise on how states and international institutions grapple with these global problems

**The Routledge Companion to Journalism Ethics** Lada Trifonova Price, Karen Sanders, Wendy N. Wyatt, 2021-08-24 This volume provides a comprehensive discussion of enduring and emerging challenges to ethical journalism worldwide The collection highlights journalism practice that makes a positive contribution to people's lives investigates the link between institutional power and ethical practices in journalism and explores the relationship between ethical standards and journalistic practice Chapters in the volume represent three key commitments 1 ensuring practice informed by theory 2 providing professional guidance to journalists and 3 offering an expanded worldview that examines journalism ethics beyond traditional boundaries and borders With input from over 60 expert contributors it offers a global perspective on journalism ethics and embraces ideas from well known and emerging journalism scholars and practitioners from around the world The Routledge Companion to Journalism Ethics serves as a one stop shop for journalism ethics scholars and students as well as industry practitioners and experts Chapter 45 of this book is freely available as a downloadable Open Access PDF at <http://www.taylorfrancis.com> under a Creative Commons Attribution Non Commercial No Derivatives CC BY NC ND 4.0 license

**The Complete Oil Painter** Brian Gorst, 2004-01-01 Oils are perhaps the most versatile of all paint mediums Yet for many artists oil painting is either shrouded in mystique or considered very difficult Filled with clear step by step instructions and surefire strategies The Complete Oil Painter is an essential one stop guide to becoming an expert in every aspect of this medium Artists will discover everything they need to know about materials pigments supports canvases tools and equipment palettes brushes paint application wet into wet alla prima glazing impasto form and color light and dark expression color mixing exploring themes still life portraiture figure painting and much more

**Camera**, 1916 **Anti-individualism and Knowledge** Jessica Brown, 2004 A persuasive monograph that answers the key epistemological arguments against anti individualism in the philosophy of mind *Semantic Externalism* Jesper Kallestrup, 2013-03 Semantic externalism is the view that the meanings of referring terms and the contents of beliefs that are expressed by those terms are not fully determined by factors internal to the speaker but are instead bound up with the environment The debate about semantic externalism is one of the most important but difficult topics in philosophy of mind

and language and has consequences for our understanding of the role of social institutions and the physical environment in constituting language and the mind In this long needed book Jesper Kallestrup provides an invaluable map of the problem Beginning with a thorough introduction to the theories of descriptivism and referentialism and the work of Frege and Kripke Kallestrup moves on to analyse Putnam s Twin Earth argument Burge s arthritis argument and Davidson s Swampman argument He also discusses how semantic externalism is at the heart of important topics such as indexical thoughts epistemological skepticism self knowledge and mental causation Including chapter summaries a glossary of terms and an annotated guide to further reading *Semantic Externalism* an ideal guide for students studying philosophy of language and philosophy of mind [Camera Craft](#) ,1905 [The Wesleyan Tradition](#) Michael Collier,2012-08-22 Since issuing its first volumes in 1959 the Wesleyan poetry program has challenged the reigning aesthetic of the time and profoundly influenced the development of American poetry One of the country s oldest programs its greatest achievement has been the publication of early works by yet undiscovered poetry who have since become major awarded Pulitzer and Bollingen prizes National Book Awards and many other honors At a time when other programs are being phased out Wesleyan takes this opportunity to celebrate its distinguished history and reaffirm its commitment to poetry with publication of *The Wesleyan Tradition* Drawing from some 250 volumes editor Michael Collier documents the wide ranging impact of these works In his introduction he describes the literary and cultural context of American poetics in more recent decades tracing the evolution of the Deep Image and Confessional movements of the 50s and 60s and exploring the emergence of the prose lyric style Although the success of the Wesleyan program has inspired its share of imitators no other program has had such a fundamental impact Works by the eighty six poets included here both document and celebrate that contribution **Encyclopedia of American Poetry: The Twentieth Century** Eric L. Haralson,2014-01-21 The Encyclopedia of American Poetry The Twentieth Century contains over 400 entries that treat a broad range of individual poets and poems along with many articles devoted to topics schools or periods of American verse in the century Entries fall into three main categories poet entries which provide biographical and cultural contexts for the author s career entries on individual works which offer closer explication of the most resonant poems in the 20th century canon and topical entries which offer analyses of a given period of literary production school thematically constructed category or other verse tradition that historically has been in dialogue with the poetry of the United States

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great will be their peace dear god i invite your presence into the kindergarten classrooms where my kid learns daily asking that you transform them into spaces of joy growth and wonder

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*least mean square adaptive filter in matlab and c github* - May 12 2023

web apr 15 2014 in april 2014 as a follow up to an interview i decided to code a simple floating point nlms adaptive filter and an accompanying test routine as an exercise starting with a matlab prototype followed by a c implementation

*pdf hardware implementation of nlms algorithm for* - Mar 30 2022

web jan 1 2010 in this work an attempt is to be made to de noise an ecg signal with the help of adaptive nlms algorithm implemented on tms320c6713 dsp processor in real time environment

*active noise cancellation functions in matlab and c github* - Aug 15 2023

web nov 26 2016 active noise cancellation functions in matlab and c a bunch of functions implementing active noise cancellation using various lms algorithms fxlms fulms nlms in matlab and c i wrote these as part of my final project for an audio signal processing class during my masters

adaptive noise cancellation using nlms algorithm - Sep 04 2022

web feb 14 2019 this paper studies the behaviour of normalized least mean square nlms adaptive filter algorithm based noise canceller to eliminate intense background noise of high and low frequency from a desired signal

**least mean squares filter wikipedia** - Mar 10 2023

web least mean squares lms algorithms are a class of adaptive filter used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean square of the error signal difference between the desired and the actual signal

github alexgrusu lmso algorithm an optimized lms algorithm - Dec 07 2022

web lmso algorithm the least mean square lms and the normalized least mean square nlms algorithms require a trade off between fast convergence and low misadjustment obtained by choosing the control parameters in general time variable



parameters are proposed according to different rules

[nlms algorithm demo file exchange matlab central](#) - Feb 26 2022

web mar 31 2016 overview functions version history reviews 20 discussions 5 nlms is one of the adaptive filter algorithms in this file an experiment is made to identify a linear noisy system with the help of nlms algorithm the weights of the estimated system is nearly identical with the real one

[implementation in c of least mean square lms algorithm](#) - Jul 02 2022

web may 27 2013 in a project for my bachelor of science degree i have to implement in c a lms algorithm the algorithm is put in an iir notch filter the error signal for the adaptive filter is  $e(n) = y(n) - \hat{y}(n)$  i implemented the algorithm but it doesn't work i applied a signal at the input of the filter the signal is a sinusoid limited at half of the amplitude

**nlms github topics github** - Jun 13 2023

web jun 30 2023 this repository represents the implementation of a normalized least mean squares nlms and a least mean squares lms adaptive filters adaptive filtering nlms lms algorithm normalized least square filters updated on jun 30 matlab

**lms algorithm github topics github** - Feb 09 2023

web jul 30 2023 code issues pull requests various melodic noise filtering techniques viz adaptive noise cancellation spectral methods and deep learning algorithms have been employed to filter music signals corrupted with additive gaussian white noise

**normalised least mean squares c implementation** - Jul 14 2023

web i'm looking to implement the normalised least mean squares nlms in c my issue is in the weight update i think as i'm running it against a standard matlab library this is the matlab code that works

**elec 301 project** - Aug 03 2022

web the c code is our program for implementation of noise cancellation on a texas instruments c6x evm the actual lms algorithm is implemented in the serialportrcvusr function the surrounding code handles a d d a and i o

*hvjay3 normalized lms algorithm interference canceling* - Jan 08 2023

web the report evaluates performance of nlms algorithm considering both cases when the signal is assumed to have similar characteristics throughout and when it is not the main objective of our algorithm is to determine filter coefficients which will try to match the filter output as close as to the desired output

[signal enhancement using lms and nlms algorithms](#) - Apr 30 2022

web signal enhancement using lms and nlms algorithms using the least mean square lms and normalized lms algorithms extract the desired signal from a noise corrupted signal by filtering out the noise both these algorithms are available with the dsp lmsfilter system object

*kocaelimakine com* - Dec 27 2021

web kocaelimakine com

matlab nlms algorithm is not converging multiple - Jan 28 2022

web sep 2 2015 the normalized least mean square algorithm is used in digital filtering it basically tries to imitate an unknown filter so their difference which is considered the error tends to zero the factor of convergence is that the error will start very high and with the continuous run of the algorithm it will be smaller

*an overview on optimized nlms algorithms for acoustic echo* - Nov 06 2022

web nov 19 2015 the jo nlms algorithm requires the estimation of three main parameters i e  $\sigma_x^2$   $\sigma_v^2$  and  $\sigma_w^2$  the first one can be easily evaluated as in the nlms algorithm i e  $\widehat{\sigma_x^2} = \frac{1}{n} \sum_{t=1}^n \mathbf{x}^T \mathbf{x}$

**active noise cancellation using adaptive filter algorithms** - Jun 01 2022

web noise cancellation using adaptive filter algorithms i least mean square lms algorithm in the lms algorithm the coefficients are adjusted from sample to sample in such a way as to minimize the mean square error mse the lms is based on the steepest descent algorithm where the weight vector is updated from

*normalized least mean square nlms padasip 1 2 1* - Apr 11 2023

web the nlms is extension of lms filter see least mean square lms for explanation of the algorithm behind the extension is based on normalization of learning rate the learning rate  $\mu$  is replaced by learning rate  $\eta_k$   $\eta_k$  normalized with every new sample according to input power as follows

a nonparametric vss nlms algorithm ieee journals - Oct 05 2022

web sep 18 2006 a nonparametric vss nlms algorithm abstract the aim of a variable step size normalized least mean square vss nlms algorithm is to try to solve the conflicting requirement of fast convergence and low misadjustment of the nlms algorithm