

**2021 United States National  
Committee of URSI National  
Radio Science Meeting  
(USNC-URSI NRSM 2021)**

**Boulder, Colorado, USA  
4 – 9 January 2021**



**IEEE Catalog Number: CFP21USN-POD  
ISBN: 978-1-7281-8460-9**

**Copyright © 2021, the authors; United States National Committee for the International Union of Radio Science (USNC-URSI) and University of Colorado Boulder  
All Rights Reserved**

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP21USN-POD
ISBN (Print-On-Demand):	978-1-7281-8460-9
ISBN (Online):	978-1-946815-12-5

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# TABLE OF CONTENTS

## **A1: ELECTROMAGNETIC METROLOGY - ANTENNAS**

### **A1.3: ANTENNA COMPARISON FOR ADDITIVE MANUFACTURING VERSUS TRADITIONAL MANUFACTURING METHODS .....3**

*Gregory Mitchell, Theodore Anthony, Army Research Laboratory, United States; Zachary Larimore, Paul Parson, DeLUX Engineering, United States*

### **A1.4: A COMPACT BEAM STEERING DIELECTRIC RESONATOR ANTENNA FOR WIRELESS POWER TRANSFER .....5**

*Reza Karimian, George Washington University, United States; Mansoor Dashti Ardakani, Institut National de la Recherche Scientifique (INRS), Canada; Behzad Koosha, Shahrokh Ahmadi, Mona Zaghloul, George Washington University, United States*

## **BE: HIGH POWER ELECTROMAGNETICS**

### **BE.1: PROPER ORTHOGONAL DECOMPOSITION FOR ANALYSIS OF HIGH-POWER VIRTUAL CATHODE OSCILLATIONS .....8**

*Julio de Lima Nicolini, Fernando Teixeira, The Ohio State University, United States*

### **BE.2: REVIEW OF ELECTRICAL - POWER TRANSFORMER RESPONSES TO FAST TRANSIENTS ..... 10**

*D. V. Giri, University of New Mexico, United States; F. M. Tesche, EMConsultant, United States*

### **BE.3: FULL-WAVE TRANSMISSION LINE THEORY (FWTLT) FOR A THIN-WIRE TRANSMISSION LINE INSIDE A RECTANGULAR RESONATOR ..... 12**

*Sergey Tkachenko, Juergen Nitsch, Moustafa Raya, Ralf Vick, Otto-von-Guericke University Magdeburg, Germany*

### **BE.4: MODELING AND STATISTICAL CHARACTERIZATION OF ELECTROMAGNETIC COUPLING TO ELECTRONIC DEVICES ..... 14**

*James Hunter, Shengxuan Xia, Aaron Harmon, Missouri University of Science & Technology, United States; Ahmed Hassan, University of Missouri-Kansas City, United States; Victor Khilkevich, Daryl Beetner, Missouri University of Science & Technology, United States*

### **BE.6: THE SCIENCE OF ELECTRONICS IN EXTREME ELECTROMAGNETIC ENVIRONMENTS I - COUPLING ..... 17**

*Edl Schamiloglu, Sameer Hemmady, Zhen Peng, Ghadeh Hadi, Evelyn Dohme, Shen Lin, University of New Mexico, United States; Thomas Antonsen, Jr., Steven Anlage, Ed Ott, University of Maryland, United States*

### **BE.7: THE SCIENCE OF ELECTRONICS IN EXTREME ELECTROMAGNETIC ENVIRONMENTS II - CIRCUIT EFFECTS ..... 19**

*Sameer Hemmady, Edl Schamiloglu, University of New Mexico, United States*

### **BE.9: A CONCEPT OF A MESOBAND SOURCE COMBINING A REFLECTARRAY ANTENNA AND A SWITCHED OSCILLATOR ..... 22**

*Felix Vega, Fernando Albarracin-Vargas, Chaouki Kasmi, Technology Innovation Institute, United Arab Emirates*

## **C1: RF SYSTEMS, PROCESSING, AND INTERFERENCE MITIGATION**

### **C1.4: CLUTTER REMOVAL OF GPR DATA USING COMPLEX NATURAL RESONANCE EXTRACTION..... 27**

*John Pantoja, Technology Innovation Institute, United Arab Emirates; Eder F. Ruiz, Universidad Nacional de Colombia, Colombia; Felix Vega, Technology Innovation Institute, United Arab Emirates; Daniel Chaparro-Arce, Universidad Nacional de Colombia, Colombia; Chaouki Kasmı, Technology Innovation Institute, United Arab Emirates*

### **C1.5: A SECURE TELECOMMUNICATION LINK USING SPREAD SPECTRUM TECHNIQUE FOR 5G APPLICATIONS ..... 29**

*Marzie Tabatabaefar, Mansoor Dashti Ardakani, Institut National de la Recherche Scientifique (INRS), Canada; Reza Karimian, George Washington University, United States; Serioja Ovidiu Tatu, Institut National de la Recherche Scientifique (INRS), Canada*

## **B1: ANTENNAS AND SENSORS FOR HARSH ENVIRONMENTS**

### **B1.3: THE VARIATION OF WEARABLE AND IMPLANTED ANTENNAS' PERFORMANCE DUE TO BODY TEMPERATURE ..... 40**

*Sima Noghianian, Wafer LLC and Sand Diego State University, United States; Josh Stout, PADT Inc., United States*

### **B1.4: ON THE EFFECT OF 2-D HEXAGONAL BORON NITRIDE FOR RADIO FREQUENCY CIRCUITS IN HARSH ENVIRONMENTS ..... 42**

*Ahsan Aqueeb, Venkataramana Gadhamshetty, Sayan Roy, South Dakota School of Mines & Technology, United States*

## **B3: COMPLEX EM AND META STRUCTURES**

### **B3.2: INTRODUCING INKJET PRINTING TECHNOLOGY TO THE FABRICATION OF FLAT-LAYERED META-LENS ANTENNAS ..... 49**

*Anastasios Papathanasopoulos, University of California, Los Angeles, United States; Ryan A. Bahr, Yepu Cui, Manos M. Tentzeris, Georgia Tech, United States; Yahya Rahmat-Samii, University of California, Los Angeles, United States*

### **B3.4: EXCEPTIONAL POINTS OF DEGENERACY IN A TRANSMISSION LINE PERIODICALLY LOADED WITH GAIN AND RADIATION LOSS ..... 52**

*Ehsan Hafezi, Ahmed Abdelshafy, Tarek Mealy, Alireza Nikzamir, Filippo Capolino, University of California, Irvine, United States*

## **A2: ELECTROMAGNETIC METROLOGY - MILLIMETER WAVE COMMUNICATIONS**

### **A2.5: VERIFICATION OF AN EVALUATOR FOR A NEW-RADIO CHANNEL ESTIMATOR..... 64**

*Alec Weiss, Atef Elsherbeni, Colorado School of Mines, United States; Jeanne Quimby, National Institute of Standards and Technology, United States*

## **B2: ANTENNA THEORY, DESIGN, AND MEASUREMENTS**

### **B2.1: RECONFIGURABLE LEAKY WAVE ANTENNA BASED ON EMBEDDED LIQUID CRYSTAL..... 71**

*Elahehsadat Torabi, Pai-Yen Chen, Danilo Erricolo, University of Illinois at Chicago, United States*

### **B2.4: BANDWIDTH ENHANCED FOLDED UNIPOLE ANTENNA FOR VLF MEASUREMENTS..... 75**

*Patrick Deibler, Ashanthi Maxworth, University of Southern Maine, United States*

## **B4: NUMERICAL METHODS**

### **B4.1: ELECTROMAGNETIC MODELING OF THIN WIRE WITH MULTILAYERED COATING IN LAYERED MEDIA ..... 86**

*Chaoxian Qi, Shubin Zeng, Xuqing Wu, Jiefu Chen, University of Houston, United States; Jiuping Chen, Yueqin Huang, Cyentech Consulting LLC, United States*

### **B4.3: EXTRACTION OF NONLINEAR X-PARAMETERS FROM FDTD SIMULATION OF A ONE-PORT DEVICE ..... 89**

*Joshua Kast, Atef Elsherbeni, Colorado School of Mines, United States*

## **C2: SENSOR ARRAY PROCESSING, IMAGING, AND AI/ML**

### **C2.2: ACCURACY: ADAPTIVE CALIBRATION OF CUBESAT RADIOMETER CONSTELLATIONS ..... 96**

*John Bradburn, Mustafa Aksoy, Henry Ashley, University at Albany, State University of New York, United States*

### **C2.6: DEEP LEARNING ENHANCED JOINT GEOPHYSICAL INVERSION FOR CROSSWELL MONITORING ..... 101**

*Yanyan Hu, Yuchen Jin, Xuqing Wu, Jiefu Chen, Jiuping Chen, Qiuyang Shen, Yueqin Huang, University of Houston, United States*

## **F2: MEMORIAL SESSION FOR V.I. TATARSKII: PART II**

### **F2.1: REMARKS ON THE PARABOLIC EQUATION MODEL FOR WAVES IN RANDOM MEDIA..... 103**

*Saba Mudaliar, Air Force Research Laboratory, United States*

### **F2.4: A SPACE-ANGLE DISCONTINUOUS GALERKIN METHOD FOR ONE-DIMENSIONAL CYLINDRICAL RADIATIVE TRANSFER EQUATION WITH ANGULAR DECOMPOSITION ..... 107**

*Hang Wang, Reza Abedi, University of Tennessee Space Institute, United States; Saba Mudaliar, Air Force Research Laboratory, United States*

## **B5: ANTENNA ARRAYS**

### **B5.2: SIMPLE PATTERN SYNTHESIS FOR COMPLICATED ARRAYS ..... 111**

*Steven Ellingson, Virginia Tech, United States*

### **B5.3: 360° SWITCHED BEAM SIW HORN ARRAYS AT 60 GHZ, PHASE CENTERS, AND FRIIS EQUATION ..... 113**

*Prabhat Baniya, Kathleen Melde, University of Arizona, United States*

### **B5.4: LOSSY BEAM GENERATION OF CIRCULAR ARRAYS..... 115**

*Kristopher Buchanan, Naval Information Warfare Center Pacific, United States; Nam Nicholas Mai, Naval Information Warfare Center Pacific; The Pennsylvania State University, United States; Sara Wheeland, Carlos Flores-Molina, Naval Information Warfare Center Pacific, United States; Gregory Huff, Pennsylvania State University, United States*

## **K2: THERAPEUTIC AND REHABILITATIVE APPLICATIONS**

### **K2.1: BOVINE CALF SERUM: BROADBAND DIELECTRIC PROPERTIES AND AN EMULATING PHANTOM ..... 131**

*Vigyanshu Mishra, Zeke Dalisky, Asimina Kiourti, The Ohio State University, United States*

## **B7: ANTENNAS FOR CUBESATS AND UAVS**

<b>B7.2: A DEPLOYABLE HEXAGONAL REFLECTARRAY ANTENNA FOR SPACE APPLICATIONS .....</b>	<b>136</b>
<i>Antonio Rubio, Abdul-Sattar Kaddour, Stavros Georgakopoulos, Florida International University, United States; Collin Ynchausti, Spencer Magleby, Larry Howell, Brigham Young University, United States</i>	

<b>B7.5: BEAM FOCUSING BY SCATTERING FROM AN ARRAY OF SCATTERERS ON A DRONE .....</b>	<b>140</b>
<i>Neil Egarguin, University of the Philippines Los Baños, Philippines; David Jackson, Daniel Onofrei, Julien Leclerc, Aaron Becker, University of Houston, United States</i>	

## **FGH: GNSS AND RADIO BEACON REMOTE SENSING**

<b>FGH.1: MEASURING GPS EIRP IN REAL-TIME WITH A SPACEBORNE GNSS-REFLECTOMETRY .....</b>	<b>146</b>
<b>REMOTE SENSING SYSTEM</b>	
<i>Tianlin Wang, Christopher Ruf, University of Michigan, United States</i>	

## **B8: 5G AND MILLIMETER WAVE ANTENNAS AND APPLICATIONS**

<b>B8.1: A KIRIGAMI-INSPIRED PATTERN-RECONFIGURABLE ANTENNA WITH SWITCHABLE .....</b>	<b>151</b>
<b>OMNIDIRECTIONAL AND UNIDIRECTIONAL BEAMS</b>	
<i>Qianyi Li, Ting-Yen Shih, University of Idaho, United States</i>	

<b>B8.2: FABRICATION AND CHARACTERIZATION OF A 900-ELEMENT 222.5 GHZ SINGLE-BIT .....</b>	<b>153</b>
<b>REFLECTIVE SURFACE WITH SUPPRESSED QUANTIZATION LOBES</b>	
<i>Bharath Kashyap, Panagiotis Theofanopoulos, Yiran Cui, Georgios Trichopoulos, Arizona State University, United States</i>	

## **GH: METEORS, ORBITAL DEBRIS, AND DUSTY PLASMAS**

<b>GH.3: A STUDY OF THE CORRELATION BETWEEN ENHANCED LHR, VLF TURBULENCES AND .....</b>	<b>160</b>
<b>EARTHQUAKES</b>	
<i>Ashanthi Maxworth, University of Southern Maine, United States; Mark Golkowski, University of Colorado Denver, United States; Gareth Perry, New Jersey Institute of Technology, United States</i>	

## **K3: ELECTROMAGNETIC IMAGING AND SENSING APPLICATIONS**

<b>K3.1: TOWARD NON-INVASIVE CORE BODY TEMPERATURE SENSING .....</b>	<b>164</b>
<i>Katrina Guido, Alexandra Bringer, Asimina Kiourti, The Ohio State University, United States</i>	

<b>K3.5: WEARABLE LOOPS FOR UNOBTUSIVE ELECTROMAGNETIC DETECTION OF JOINT .....</b>	<b>169</b>
<b>EFFUSION</b>	
<i>Zeke Dalisky, Vidyanshu Mishra, Asimina Kiourti, The Ohio State University, United States</i>	

<b>K3.6: AIR-CORE COIL GRADIOMETER FOR BIOMAGNETIC SENSING IN NON-SHIELDED .....</b>	<b>171</b>
<b>ENVIRONMENTS</b>	
<i>Keren Zhu, Asimina Kiourti, The Ohio State University, United States</i>	

<b>K3.7: ARTIFACTS OF CAPTURING UNINTENTIONAL RF ENERGY TRANSFER DURING IN VITRO .....</b>	<b>173</b>
<b>TONSILLECTOMY</b>	
<i>Vidyanshu Mishra, The Ohio State University, United States; Weston Niermeyer, Tendy Chiang, Nationwide Children's Hospital, United States; Asimina Kiourti, The Ohio State University, United States</i>	

<b>K3.8: A WIRELESS POWER TRANSFER SYSTEM ON CLOTHES USING CONDUCTIVE THREADS .....</b>	<b>175</b>
<i>Juan Barreto, Abdul-Sattar Kaddour, Stavros Georgakopoulos, Florida International University, United States</i>	
<b>B9: MICROSTRIP AND PRINTED ANTENNAS AND DEVICES</b>	
<b>B9.3: CURVING EFFECT ON THE CURVED TRAPEZOID PATCH FOR ON-WRIST POWER ..... HARVESTING AT 2.45 GHZ .....</b>	<b>180</b>
<i>Moein Noferesti, Tarek Djerafi, Institut National de la Recherche Scientifique (INRS), Canada</i>	
<b>B9.4: WIDEBAND PROXIMITY-FED LOW PROFILE CIRCULARLY POLARIZED PATCH ANTENNA .....</b>	<b>182</b>
<i>Christian Cavalier, Brad Jackson, California State University, Northridge, United States</i>	
<b>B9.5: VOLTAGE PULSE PROPAGATION ON A DISPERSIVE MICROSTRIP TRANSMISSION LINE .....</b>	<b>184</b>
<i>Katherine Aho, Kurt E. Oughstun, University of Vermont, United States</i>	
<b>B9.6: HIGH ISOLATION AND HIGH GAIN PLANAR PATCH ARRAY FOR IN-BAND FULL-DUPLEX ..... APPLICATIONS .....</b>	<b>186</b>
<i>Tuan Nguyen, Tutku Karacolak, Washington State University, United States</i>	
<b>B9.9: DESIGN OF A NON-RECIPROCAL RECONFIGURABLE PHASE SHIFTER FOR PHASED ARRAY ..... APPLICATIONS .....</b>	<b>190</b>
<i>Reza Karimian, George Washington University, United States; Mansoor Dashti Ardakani, Institut National de la Recherche Scientifique (INRS), Canada; Shahrokh Ahmadi, Mona Zaghloul, George Washington University, United States</i>	
<b>F4: MICROWAVE REMOTE SENSING OF THE EARTH: I</b>	
<b>F4.6: A SIGNAL SUB-SPACE BASED APPROACH FOR MITIGATING WIND TURBINE CLUTTER IN ..... FAST SCANNING WEATHER RADAR .....</b>	<b>202</b>
<i>Amit Dutta, Chandra.V Chandrasekar, Colorado State University, United States; Evan Ruzanski, Vaisala, United States</i>	
<b>B10: RF DESIGN AND METROLOGY FOR RADIATION AND SENSING</b>	
<b>B10.2: CIRCULARLY POLARIZED RFID TAG ANTENNA DESIGN FOR UNDERGROUND ..... LOCALIZATION SYSTEM .....</b>	<b>205</b>
<i>Yiming Chen, Atef Elsherbeni, Colorado School of Mines, United States</i>	
<b>B10.5: WIRELESS TELEMETRY SYSTEM FOR LONG-TERM REAL-TIME SUBSURFACE ..... MONITORING .....</b>	<b>209</b>
<i>Xiaoliang Li, Chenpei Huang, Debing Wei, Miao Pan, Xiaonan Shan, Jiefu Chen, University of Houston, United States</i>	
<b>B10.7: ACCURATE ON-WAFER MEASUREMENT TECHNIQUE FOR E-BAND MHEMIC ..... COMMUNICATION SYSTEMS .....</b>	<b>212</b>
<i>Mansoor Dashti Ardakani, Nima Souzandeh, Institut National de la Recherche Scientifique (INRS), Canada; Reza Karimian, George Washington University, United States; Sonia Aïssa, Serioja Ovidiu Tatu, Institut National de la Recherche Scientifique (INRS), Canada</i>	
<b>B10.9: A 3D PRINTED MICROSTRIP PATCH ANTENNA USING ELECTRIFI FILAMENT FOR ..... IN-SPACE MANUFACTURING .....</b>	<b>216</b>
<i>Dipankar Mitra, Ryan Striker, Jerika Cleveland, Benjamin Braaten, North Dakota State University, United States; Kazi Kabir, Ahsan Aqueeb, Ellie Burczek, Sayan Roy, South Dakota School of Mines &amp; Technology, United States; Shengrong Ye, Multi3D Inc., United States</i>	

# **H1: WAVES AND TURBULENCE IN LABORATORY AND SPACE PLASMAS**

## **H1.3: ELECTROSTATIC WAVES WITH RAPID FREQUENCY SHIFTS IN THE SOLAR WIND FROM ..... 220**

### **PSP OBSERVATIONS**

*Lily Kromyda, David Malaspina, Robert Ergun, University of Colorado Boulder / Laboratory of Atmospheric and Space Physics, United States; Jasper Halekas, University of Iowa, United States; Michael Stevens, Harvard-Smithsonian Center for Astrophysics, United States; Jennifer Verniero, University of California, Berkeley / Space Sciences Laboratory, United States; Alexandros Chasapis, Daniel Vech, University of Colorado Boulder / Laboratory of Atmospheric and Space Physics, United States; Stuart Bale, John Bonnell, University of California, Berkeley / Space Sciences Laboratory, United States; Thierry Dudok de Wit, LPC2E, CNRS, and University of Orleans, France; Keith Goetz, University of Minnesota, United States; Katherine Goodrich, Peter Harvey, University of California, Berkeley / Space Sciences Laboratory, United States; Robert MacDowall, NASA Goddard Space Flight Center, United States; Marc Pulupa, University of California, Berkeley / Space Sciences Laboratory, United States; Anthony Case, Harvard-Smithsonian Center for Astrophysics, United States; Justin Kasper, University of Michigan Ann Arbor, United States; Kelly Korreck, Harvard-Smithsonian Center for Astrophysics, United States; Davin Larson, Roberto Livi, Phyllis Whittlesey, University of California, Berkeley / Space Sciences Laboratory, United States*

## **D1: ELECTRONIC DEVICES, CIRCUITS, AND APPLICATIONS**

### **D1.3: A 10MHZ-1GHZ MITIGATED SHUNT CAPACITANCE HYBRID LNA FOR USE IN A KA-BAND ..... 226**

#### **ENVELOPE DETECTOR BASEBAND OUTPUT**

*Nicholas Estes, Jonathan Chisum, University of Notre Dame, United States*

### **D1.6: 60-GHZ-BAND MPMC FREQUENCY MULTIPLIER MODULE FOR MULTI-PORT ..... 230**

#### **INTERFEROMETER RECEIVERS**

*Mansoor Dashti Ardakani, Institut National de la Recherche Scientifique (INRS), Canada; Reza Karimian, George Washington University, United States; Serioja Ovidiu Tatu, Institut National de la Recherche Scientifique (INRS), Canada*

## **ACEJ: SPECTRUM HARMONIZATION IN CONTENTIOUS ELECTROMAGNETIC ENVIRONMENTS**

### **ACEJ.2: UNDERSTANDING DYNAMIC SPECTRUM SHARING: FIELD TO LAB METHODOLOGY ..... 238**

#### **AND CASE STUDY**

*Darren McCarthy, Rohde & Schwarz America, United States; David Erisman, ERISYS LLC, United States*

## **B11: LOW-PROFILE ANTENNAS FROM GIGAHERTZ TO TERAHERTZ**

### **B11.2: WIDEBAND DUAL-POLARIZED LOW-PROFILE FILTERING MICROSTRIP PATCH ANTENNA..... 243**

*Sanghoon Lee, Georgia Institute of Technology, United States; Kirti Dhawaj, Indian Institute of Technology Delhi, India*

### **B11.4: DESIGN AND FABRICATION OF AN ORIGAMI MULTIMODE RING ANTENNA ..... 246**

*Nicholas Russo, Constantinos L. Zekios, Stavros Georgakopoulos, Florida International University, United States; Hyeon An, Anand Mishra, Robert Shepherd, Cornell University, United States*

## **B12: MULTISCALE AND STOCHASTIC MODELING IN COMPUTATIONAL ELECTROMAGNETICS**

### **B12.1: STOCHASTIC ANALYSIS OF HUMAN EXPOSURE ASSESSMENT BY SURROGATE MODEL..... 259**

*Botian Zhang, Yahya Rahmat-Samii, University of California, Los Angeles, United States*

### **B12.2: DYNAMIC MODE DECOMPOSITION REDUCED-ORDER MODELS FOR MULTISCALE ..... 261**

#### **KINETIC PLASMA ANALYSIS**

*Indranil Nayak, Fernando Teixeira, The Ohio State University, United States*

<b>B12.4: A PROBABILISTIC APPROACH TO RADIATED ELECTROMAGNETIC INTERFERENCE .....</b>	<b>264</b>
<i>Michael Haider, Johannes A. Russer, Technical University of Munich, Germany</i>	
<b>B12.5: STOCHASTIC FDTD MODELING OF PROPAGATION LOSS DUE TO RANDOM SURFACE .....</b>	<b>266</b>
<b>ROUGHNESS IN SIDEWALLS OF OPTICAL INTERCONNECTS</b>	
<i>Brian Guiana, Ata Zadehgo, University of Idaho, United States</i>	
<b>B12.6: CYCLOSTATIONARITY IN EMI ASSESSMENT OF PCBs .....</b>	<b>268</b>
<i>Johannes A. Russer, Michael Haider, Peter Russer, Technical University of Munich, Germany; Andrey Baev, Yury Kuznetsov, Moscow Aviation Institute, Russia</i>	