

# CONTENTS

## INTRODUCTION

<b>Preface</b> .....	ix
<b>The Political Economy of Muon-Catalyzed Fusion Research</b> .....	xi
Ryszard Gajewski	

## CHAPTER I: EXPERIMENTAL STATUS AND RESULTS

### *Invited Papers:*

<b>Survey of Experimental Results in Muon-Catalyzed Fusion</b> .....	2
Steven E. Jones	
<b>The Measurement of <math>d\&amp;-</math>Molecule Formation Rate at High Deuterium Pressure</b> .....	17
<i>V. M. Bystritsky</i> , V. P. Dzheleпов, V. V. Filchenkov, A. I. Gilev, V. B. Granovsky, Han Don Ir, N. Ilieva Sokolieva, A. D. Konin, L. Marczis, D. G. Merkulov, A. I. Rudenko, A. B. Selikov, L. N. Somov, V. A. Stolupin, and V. G. Zinov	
<b>Status of Muon-Catalyzed Fusion Experiments at UT-MSL/KEK</b> .....	23
<i>K. Nagai</i> , T. Matsuzaki, K. Ishida, Y. Hirata, Y. Watanabe, Y. Miyake, and R. Kadono	
<b>First Direct Measurement of <math>\alpha-\mu</math> sticking in <math>dt-\mu CF</math></b> .....	38
<i>M. A. Paciotti</i> , O. K. Baker, J. N. Bradbury, J. S. Cohen, M. Leon, H. R. Maltrud, L. L. Sturgess, A. N. Anderson, A. J. Caffrey, J. M. Zabriskie, F. D. Brooks, W. A. Cilliers, J. D. Davies, J. B. A. England, G. J. Pyle, G. T. A. Squire, A. Bertin, M. Bruschi, M. Piccinini, A. Vitale, A. Zoccoli, V. R. Born, C. W. E. van Eijk, H. de Haan, and G. H. Eaton	
<b><math>\mu Cf</math> Thoughts from Birmingham and the Rutherford Appleton Laboratory</b> .....	52
<i>J. D. Davies</i> , F. D. Brooks, W. A. Cilliers, J. B. A. England, G. J. Pyle, G. T. Z. Squire, A. Bertin, M. Bruschi, M. Piccinini, A. Vitale, A. Zoccoli, S. E. Jones, P. Li, L. M. Rees, E. V. Sheeley, J. K. Shurtleff, S. F. Taylor, G. H. Eaton, B. Alper, V. R. Born, C. W. E. van Eijk, H. de Haan, A. N. Anderson, A. J. Caffrey, J. Zabriskie, M. A. Paciotti, O. K. Baker, J. N. Bradbury, J. S. Cohen, M. Leon, H. R. Maltrud, and L. N. Sturgess	
<b>Investigation of <math>Q_{Ist}</math></b> .....	57
A. N. Anderson	
<b>Progress Report on Muon-Catalyzed Fusion Studies in <math>H_2 + D_2</math> and HD Gaseous Targets</b> .....	68
K. A. Aniol, A. J. Noble, D. Horvath, B. C. Robertson, M. Salomon, and S. E. Jones	

### *Contributed Papers:*

<b>Predicted Methods of Changing the Muon-Catalyzed Fusion Cycling Rate</b> .....	79
E. V. Sheely, S. E. Jones, L. M. Rees, J. K. Shurtleff, S. F. Taylor, and J. M. Thome	

## CHAPTER 2: THEORETICAL MUOCHEMISTRY

### *Invited Papers:*

<b>Theoretical Survey of <math>\mu\text{CF}</math></b> .....	94
M. Leon	
<b>Possible Influence of Vacuum Polarization on <math>Q_{\mu}</math> in Muon-Catalyzed</b>	
<b>D-T Fusion</b> .....	105
<i>B. Müllerc</i> J. Rafelski, M. Jandel, and S. E. Jones	
<b>Pressure Broadening of the <math>[(d\mu)\text{dec}]^*</math> Formation Resonances</b> .....	111
J. S. Cohen, M. Leon, and <i>N. T. Padial</i>	
<b>Formation of Hydrogen Mesic Molecules at Moderate Gas Densities</b> .....	124
V. Yu. Petrov and <i>Yu. V. Petrov</i>	
<b>Slowing-Down and Coulomb Capture of Negative Muons in Molecular Hydrogen</b> .....	145
<i>G. Ya. Korenman</i> and V. P. Popov	
<b>Muon Losses in Deuterium-Tritium Muon-Catalyzed Fusion Due to Fast Transfer Reactions to Helium Nuclei</b> .....	161
A. <i>Bertin</i> , M. Bruschi, M. Capponi, J. D. Davies, S. De Castro, <i>I. Massa</i> , M. Piccinini, M. Poli, N. Semprini-Cesari, A. Trombini, <i>A. Vitale</i> , and A. Zoccoli	
<b>Increase in Meso-Molecular Formation by Laser-Induced Resonances</b> .....	169
<i>S. Barnett</i> and A. M. Lane	
<b>Laser Induced P-Molecular Formation</b> . . . . .	178
S. Eliezer and <i>Z. Henis</i>	
<b>Muonic Molecular Formation Under Laser Irradiation and in the Clustered Ion Molecule (The Effect of Protonium Additive on the Muon-Catalyzed Fusion Cycle)</b> .....	185
Hiroshi Takahashi	
<b>Considerations for <math>\mu\text{CF}</math> Experiments with Metastably Spin-Polarized</b>	
<b>D and T</b> .....	199
<i>A. Honig</i> , N. Alexander, and S. Yucel	

### *Contributed Papers:*

<b>Spin Flip Rates in Collisions Between Muonic Atoms</b> .....	214
L. Bracci, C. Chiccoli, P. Pasini, G. Fiorentini, V. S. Melezhik, and J. Wozniak	
<b>Molecular Effects in Muonic Hydrogen Cascade</b> .....	217
D. Taqqu	
<b>Molecular Effects in Nuclear Scattering: Hyperfine Quenching in <math>d\mu + D_2</math> Collisions</b> .....	223
O. K. Baker	
<b>A Direct Process for Meso Molecule Formation at High Temperature</b> .....	226
A. M. Lane	
<b>Capture of a Classical Muon by a Quanta1 Hydrogen Atom</b> .....	236
N. H. Kwong, J. D. Garcia, and <i>J. S. Cohen</i>	
<b>MuCF with <math>Z &gt; 1</math></b> .....	239
D. Harley, B. Müller, and J. Rafelski	

### CHAPTER 3: PROPERTIES OF MUOMOLECULES

#### *Invited Papers:*

<b>A Comparison of Muonic Molecular Calculations</b> .....	246
S. A. Alexander, H. J. Monkhorst, and K. Szalewicz	
<b>Some Properties of Three Body Resonances of <math>d\mu</math> Related To Muon-Catalyzed Fusion</b> .....	259
P. Froelich, K. Szalewicz, H. J. Monkhorst, W. Kolos, and B. Jeziorski	
<b>Theoretical Description of Muonic Molecular Ions</b> .....	274
K. Szalewicz, S. A. Alexander, P. Froelich, S. E. Haywood, B. Jeziorski, W. Kolos, H. J. Monkhorst, A. Scrinzi, C. Stodden, A. Velenik, and X. Zhao	

#### *Contributed Papers:*

<b>Correction to the Binding Energy of (<math>d\mu</math>) Meso Molecules</b> .....	289
A. M. Lane	
<b>Integral Transform Wavefunctions in the Solution of the Quantum Mechanical Three Body Problem</b> .....	295
Vedene H. Smith, Jr. and Piotr Petelenz	
<b>De-Excitation of Muonic Molecules by Internal Conversion</b> .....	303
A. K. Bhatia, R. J. Drachman, and L. Chatterjee	

### CHAPTER 4: MUON STICKING AND MUON REGENERATION

#### *Invited Papers:*

<b>Comprehensive Theory of Nuclear Effects on the Intrinsic Sticking Probability: I</b> .....	308
M. Danos, L. C. Biedenharn, and A. Stahlhofen	
<b>Comprehensive Theory of Nuclear Effects on the Intrinsic Sticking Probability: II</b> .....	320
M. Danos, L. C. Biedenharn, and A. Stahlhofen	
<b>Effect of Nuclear Interaction on Muon Sticking to Helium in Muon-Catalyzed d-t Fusion</b> .....	330
M. Kamimura	
<b>Boundary-Value Approach to Nuclear Effects in Muon-Catalyzed D-T Fusion</b> .....	344
G. M. Hale, M. C. Struensee, R. T. Pack, and J. S. Cohen	
<b>Density Dependent Stopping Power and Muon Sticking in Muon-Catalyzed D-T Fusion</b> .....	355
H. E. Rafelski and B. Müller	
<b>A Proposed Method for Reducing the Sticking Constant in M.C.F.</b> .....	367
R. M. Kulsrud	

#### *Contributed Papers:*

<b>A First Born Approximation Calculation of the Total Cross-Section for Ionization of the <math>\alpha\mu^+</math> Ion by Collision with a Deuteron</b> .....	381
G. C. Larson and P. Froelich	
<b>Estimation of Error in Using Born Scaling for Collision Cross Sections Involving Muonic Ions</b> .....	388
C. D. Stodden, H. J. Monkhorst, and K. Szalewicz	

## CHAPTER 5: MUON PRODUCTION

### *Invited Papers:*

<b>Optimal Active Targets for Muon-Catalyzed Fusion Reactions</b> .....	<b>394</b>
M. Jändel	
<b>On the Energy Cost of Producing Muons in a Deuterium-Tritium Target for Muon-Catalyzed Fusion</b> .....	<b>405</b>
A. Bertin, M. Bruschi, M. Capponi, S. De Castro, I. Massa, M. Piccinini, M. Poli, N. Semprini-Cesari, A. Trombini, A. Vitale, and A. Zoccoli	
<b>Pion (and Muon) Production by Antiprotons on Light and Heavy Nuclei</b> .....	<b>415</b>
R. A. Lewis, E. Minor, F. Persi, G. A. Smith, W. Toothacker, and J. Whitmore	
<b>A New Concept for Muon-Catalyzed Fusion Reactor</b> .....	<b>423</b>
T. Tajima, S. Eliezer, and R. M. Kulsrud	

### *Contributed Papers:*

<b>On Heavy Ion Collisions as a Muon Source</b> .....	<b>435</b>
L. Chatterjee and D. Ghosh	

## CHAPTER 6: SUMMARY AND CONCLUSIONS

<b>Fission: An Object Lesson for Fusion*</b> .....	<b>440</b>
Alvin M. Weinberg	
<b>The Challenges of Muon-Catalyzed Fusion</b> .....	<b>451</b>
J. Rafelski	
<b>List of Participants</b> .....	<b>465</b>