CURRICULUM: SCIENCES AND TECHNOLOGIES FOR AERONAUTICS AND SATELLITE APPLICATIONS (STASA)





# MODELLING SPRAY DYNAMICS FOR EVAPORATION AND COMBUSTION

DOCTOR STUDENT: **Jietuo WANG** SUPERVISOR: **Prof. Francesco Picano** DATE: 10/26/2018



# OUTLINE OF THE PRESENTATION

- Introduction Part
- What's New
- Summary of The Research Activity

## Introduction – What Is The Spray Evaporation & Combustion?





- A turbulent spray is a chaotic multiphase flow where chemical reactions occur together with phase exchange during combustion.
- The different physical phenomena involved range from submicron-scale, e.g. reactions, to meter size turbulent motions.

### Introduction – How It Looks Like in Practical Applications?





#### High-Speed Schlieren Movies of Diesel Sprays (Sandia National Lab)

Similar phenomena happen in car engines, ship engines, airplane engines and liquid rocket engines.

# Introduction – Why Is It Important to Study The Phenomena?

- Improving combustion efficiency
  - More chemical energy transfer into works available
  - Less fuel consumption
- Reducing pollutant emission levels
  - Particular Matter (PM)
  - NOx
  - CO
  - Greenhouse Gas
  - .....



# Introduction – State of The Art



LES coupled with Reduced Chemical Mechanism / Combustion Model is a promising method to analyzing the turbulent spray phenomena.

6



#### **Dilute regime & very dilute regime:**

- Dispersed droplets
- No Break-up : surface tension >> aer. forces (We << 1)</p>
- > No collision / coalescence : low volume fraction  $(\Phi < 10-4)$
- > Main region occurring combustion



Move forward the physical and technological understanding of multiphase turbulent spray evaporation and combustion phenomena

Satisfactory code will de updated to perform 3D simulations of turbulent, evaporating and reacting sprays



9

# Prof. Francesco Picano has reliable codes in multiphase flows

The applicant has focused on analyzing combustion characteristics in internal combustion engines during his Master period

# Summary of Research Activity – Three Years



MICS FOR EVAPORATION AND COMBUSTION - Jietuo WANG (STASA)

## Summary of Research Activity - GANNT

| WBS TASK TITLE  | % OF TASK  | <b>T</b> 1   |   | Т  
   
  | 2  | Т   | 3   
   
  | T4   
   
   | 4  | <b>T</b> 1   |   | T2  
   
   |  | Т3   
  |  | <b>T4</b>  |   | <b>T1</b>  
   |   | T2  
  | T;   | 3  | <b>T</b> 4   |  |
|---|--|--|---
--
--
---|--|---
--
--
--
--
--|--|---
--
---|--
--
---|--|--|---
--|---
--|--|--|--|--|
|   | COMPLETE   | ΟΝ   | D,  | JF   
   
  | = M  | AN  | ΙJ  
   
  | JΑ   
   
   | S  | O N  | D,  | JF  
   
   | MA   | A M  
  | JJ   | Α  | S O   | N  
   | ) J   | FΜ  
  | AN   | IJ   | JA   | S  |
| Training and Bibliographical Research                                       |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  | $\overline{}$  |
| Analysis of The State of Art in Trubulent Spray Evaporation                 | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  | 0   |  
   | R   |   
  | -  |  |  |  |
| Master the Multiphase Flow Theory & High Performance Code Skills            | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   | MCCX   
   | XII   |   
  | G.C  | 0  |  | ВС   |
| Code Development and Simulation   |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Modeling for Turbulent Spray Evaporration                                   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Model Validation and Optimazation   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Simulation I: Turbulent Spray Evaporation with DNS and LES Frameworks       | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Writing Paper I   |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Collecting Data and Producing Images  | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Reporting Methodology and Results   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Admission to Year II  |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Training and Bibliographical Research                                       |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Analysis of The State of Art in Trubulent Spray Combustion                  | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Combustion  | 0%   |  |   | Т  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Code Development and Simulation   |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Partial Premixed Combustion Modeling  | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Model Validation and Optimazation   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Simulation II: Turburlent Spray Evaporation and Combustion in DNS Framework | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Writing Paper II  | ·  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Collecting Data and Producing Images  | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Reporting Methodology and Results   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Admission to Year III   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Code Development and Simulation   | •  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Coupling Combustion Model with LES  | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Model Validation and Optimazation   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Simulation3: Turbulent Spray Evaperation and Combustion with LES Model      | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Admission to Final Examination  |  |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
| Writing These and Reports   | 0%   |  |   |  
   
  |  |   |   
   
  |  
   
   |  |  |   |   
   
   |  |  
  |  |  |   |  
   |   |   
  |  |  |  |  |
|   | TASK TITLE         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation         Master the Multiphase Flow Theory & High Performance Code Skills         Code Development and Simulation         Modeling for Turbulent Spray Evaporation         Model Validation and Optimazation         Simulation 1 : Turbulent Spray Evaporation with DNS and LES Frameworks         Writing Paper I         Collecting Data and Producing Images         Reporting Methodology and Results         Admission to Year II         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Combustion         Combustion         Code Development and Simulation         Partial Premixed Combustion Modeling         Model Validation and Optimazation         Simulation <i>II</i> : Turburlent Spray Evaporation and Combustion in DNS Framework         Writing Paper II         Collecting Data and Producing Images         Reporting Methodology and Results         Admission to Year II         Collecting Data and Producing Images         Reporting Date and Producing Images         Reporting Date and Producing Images         Reporting Methodology and Results         Admission to Year III         Code Development and Simulation | TASK TITLE% OF TASK<br>COMPLETETraining and Bibliographical Research0%Analysis of The State of Art in Trubulent Spray Evaporation0%Master the Multiphase Flow Theory & High Performance Code Skills0%Code Development and Simulation0%Modeling for Turbulent Spray Evaporation with DNS and LES Frameworks0%Writing Paper I0%Collecting Data and Producing Images0%Admission to Year II0%Training and Bibliographical Research0%Analysis of The State of Art in Trubulent Spray Combustion0%Combustion0%Combustion0%Combustion0%Combustion0%Conde Development and Simulation0%Code Development and Simulation0%Code Development and Simulation0%Collecting Data and Producing Images0%Simulation II : Turburlent Spray Evaporation and Combustion in DNS Framework0%Writing Paper II0%Collecting Data and Producing Images0%Admission to Year II0%Collecting Data and Producing Images0%Admission to Year II0%Collecting Data and Producing Images0%Admission to Year II0%Coupling Combustion Model with LES0%Admission to Year III0%Coupling Combustion Model with LES0%Admission to Final Examination0%Writing These and Reports0% | TASK TITLE       % OF TASK<br>COMPLETE       T         Training and Bibliographical Research       Image: Complete Spray Evaporation       0%       Image: Spray Evaporation         Master the Multiphase Flow Theory & High Performance Code Skills       0%       Image: Spray Evaporation       0%       Image: Spray Evaporation         Modeling for Turbulent Spray Evaporation       0%       Image: Spray Evaporation       0%       Image: Spray Evaporation         Model Validation and Optimazation       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation with DNS and LES Frameworks       0%       Image: Spray Evaporation and Combustion Training and Bibliographical Research       Image: Spray Evaporation Spray Evaporation Spray Evaporation Spray Evaporation       0%       Image: Spray Evaporation and Combustion in DNS Framework       Image: Spray Evaporation and Combustion in | TASK TITLE% OF TASK<br>COMPLETETi<br>ONDTraining and Bibliographical ResearchAnalysis of The State of Art in Trubulent Spray Evaporation0%000Master the Multiphase Flow Theory & High Performance Code Skills0%0%0000Code Development and Simulation0%0%000 <td>TASK TITLE% OF TASK<br/>COMPLETETTTTTTraining and Bibliographical ResearchAnalysis of The State of Art in Trubulent Spray Evaporation0%00</td> <td>TASK TITLE% OF TASK<br/>COMPLETEII</td> <td>TASK TITLE         % OF TASK<br/>COMPLETE         Tit         <thtit< th="">         Tit<td>TASK TITLE         % OF TASK<br/>COMPLETE         1         <th1< th=""> <th1< th="">         1<td>TASK TITLE         % OF TASK         T1         T2         T3         T4         T2         T3         T4           Training and Bibliographical Research         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution of Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution Solution of Solution Solution Solution Solution Solution Solution of Solut</td><td>TASK TTLE         % OF TASK         T1         T2         T3         T4           COMPLETE         O         N         J         F         A         J         S         I         S         I         I         T2         T3         T4           COMPLETE         O         N         J         F         A         J         A         S         I         A         S         I         A         S         I         A         S         I         A         S         I         A         I         A         I         A         I         A         I</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T         Training and Bibliographical Research       ON 0 J F M A M J J A S       N J F M A M J J A S       N       N J F M A M J J A S       N         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0%       0</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T1         Training and Bibliographical Research       OND       J       F       M MJ       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A<!--</td--><td>TASK TITLE       Y       T1       T2       T3       T4
      T1       T2         Training and Bibliographical Research       O       N       J       F       N       J       A       S       O       D       J       K       N       J       A       S       O       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       K       N       D       J       K       N       D       J       K       K       N       D       K</td><td>TASK TITLE       % OF TASK<br/>COMPLEX       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0       <t< td=""><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       Yo CF TASK<br/>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      &lt;</td><td>TASK TITLE       Yo       FTASK COMPLETE       T<!--</td--><td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td><td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td></td></t<></td></td></th1<></th1<></td></thtit<></td> | TASK TITLE% OF TASK<br>COMPLETETTTTTTraining and Bibliographical ResearchAnalysis of The State of Art in Trubulent Spray Evaporation0%00 | TASK TITLE% OF TASK<br>COMPLETEII | TASK TITLE         % OF TASK<br>COMPLETE         Tit         Tit <thtit< th="">         Tit<td>TASK TITLE         % OF TASK<br/>COMPLETE         1    
    1         <th1< th=""> <th1< th="">         1<td>TASK TITLE         % OF TASK         T1         T2         T3         T4         T2         T3         T4           Training and Bibliographical Research         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution of Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution Solution of Solution Solution Solution Solution Solution Solution of Solut</td><td>TASK TTLE         % OF TASK         T1         T2         T3         T4           COMPLETE         O         N         J         F         A         J         S         I         S         I         I         T2         T3         T4           COMPLETE         O         N         J         F         A         J         A         S         I         A         S         I         A         S         I         A         S         I         A         S         I         A         I         A         I         A         I         A         I</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T         Training and Bibliographical Research       ON 0 J F M A M J J A S       N J F M A M J J A S       N       N J F M A M J J A S       N         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0%       0</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T1         Training and Bibliographical Research       OND       J       F       M MJ       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A<!--</td--><td>TASK TITLE       Y       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research       O       N       J       F       N       J       A       S       O       D       J       K       N       J       A       S       O       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       K       N       D       J       K       N       D       J       K       K       N       D       K</td><td>TASK TITLE       % OF TASK<br/>COMPLEX       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0       <t< td=""><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       Yo CF TASK<br/>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      &lt;</td><td>TASK TITLE       Yo       FTASK COMPLETE       T  
    T       T<!--</td--><td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td><td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td></td></t<></td></td></th1<></th1<></td></thtit<> | TASK TITLE         % OF TASK<br>COMPLETE         1 <th1< th=""> <th1< th="">         1<td>TASK TITLE         % OF TASK         T1         T2         T3         T4         T2         T3         T4           Training and Bibliographical Research         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution of Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution Solution of Solution Solution Solution Solution Solution Solution of Solut</td><td>TASK TTLE         % OF TASK         T1         T2         T3         T4           COMPLETE         O         N         J         F         A         J         S         I         S         I         I         T2         T3         T4           COMPLETE         O         N         J         F         A         J         A         S         I         A         S         I         A         S         I         A         S         I         A         S         I         A         I         A         I         A         I         A         I</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T         Training and Bibliographical Research       ON 0 J F M A M J J A S       N J F M A M J J A S       N       N J F M A M J J A S       N         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0%       0</td><td>TASK TITLE       % OF TASK<br/>COMPLETE       T1       T2       T3       T4       T1         Training and Bibliographical Research       OND       J       F       M MJ       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A<!--</td--><td>TASK TITLE       Y       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research       O       N       J       F       N       J       A       S       O       D       J       K       N       J       A       S       O       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       K       N       D       J       K       N       D       J       K       K       N       D       K</td><td>TASK TITLE       % OF TASK<br/>COMPLEX       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0
      0       <t< td=""><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       Yo CF TASK<br/>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      &lt;</td><td>TASK TITLE       Yo       FTASK COMPLETE       T<!--</td--><td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td><td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td></td></t<></td></td></th1<></th1<> | TASK TITLE         % OF TASK         T1         T2         T3         T4         T2         T3         T4           Training and Bibliographical Research         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of the State of Art in Trubulent Spray Evaporation         0%         Image: Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution of Solution of Solution of Turbulent Spray Evaporation with DNS and LES Frameworks         0%         Image: Solution Solution of Solution Solution Solution Solution Solution Solution of Solut | TASK TTLE         % OF TASK         T1         T2         T3         T4           COMPLETE         O         N         J         F         A         J         S         I         S         I         I         T2         T3         T4           COMPLETE         O         N         J         F         A         J         A         S         I         A         S         I         A         S         I         A         S         I         A         S         I         A         I         A         I         A         I         A         I | TASK TITLE       % OF TASK<br>COMPLETE       T1       T2       T3       T4       T         Training and Bibliographical Research       ON 0 J F M A M J J A S       N J F M A M J J A S       N       N J F M A M J J A S       N         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0%       0 | TASK TITLE       % OF
TASK<br>COMPLETE       T1       T2       T3       T4       T1         Training and Bibliographical Research       OND       J       F       M MJ       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A       N       J       A </td <td>TASK TITLE       Y       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research       O       N       J       F       N       J       A       S       O       D       J       K       N       J       A       S       O       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       K       N       D       J       K       N       D       J       K       K       N       D       K</td> <td>TASK TITLE       % OF TASK<br/>COMPLEX       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0       <t< td=""><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       Yo CF TASK<br/>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      &lt;</td><td>TASK TITLE       Yo       FTASK COMPLETE       T<!--</td--><td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td><td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td></td></t<></td> | TASK TITLE       Y       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research       O       N       J       F       N       J       A       S       O       D       J       K       N       J       A       S       O       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J       K       N       D       J 
     K       N       D       J       K       N       D       J       K       N       D       J       K       K       N       D       J       K       N       D       J       K       K       N       D       K | TASK TITLE       % OF TASK<br>COMPLEX       T1       T2       T3       T4       T1       T2         Training and Bibliographical Research         Analysis of The State of Art in Trubulent Spray Evaporation       0%       0 <t< td=""><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       % OF TASK       1       <th1< th="">       1       1</th1<></td><td>TASK TITLE       Yo CF TASK<br/>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      &lt;</td><td>TASK TITLE       Yo       FTASK COMPLETE       T<!--</td--><td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td><td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td></td></t<> | TASK TITLE       % OF TASK       1 <th1< th="">       1       1</th1<> | TASK TITLE       % OF TASK       1 
     1       1       1       1       1       1 <th1< th="">       1       1</th1<> | TASK TITLE       Yo CF TASK<br>COMPLETE       Yo R       M       J       J       A       N       J       J       A       N       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       J       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       M       J       A       A      < | TASK TITLE       Yo       FTASK COMPLETE       T </td <td>TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       <tht3< th="">       T4&lt;</tht3<></td> <td>TASK TITLE       % OF TASK       Tid       Tid<td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td><td>TASK TITLE       Y OF TASK       Y OF TASK</td><td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td><td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td></td> | TASK TITLE       % OF TASK       Ti       T2       T3       T4       T3       T4       T1       T2       T3       T4       T1       T2 <tht3< th="">       T4&lt;</tht3<> | TASK TITLE       % OF TASK       Tid       Tid <td>TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14</td> <td>TASK TITLE       Y OF TASK       Y OF TASK</td> <td>TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14</td> <td>TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$       <td< td=""></td<></td> | TASK TITLE       % OF TASK       11       12       13       14       14       14       12       13       14 | TASK TITLE       Y OF TASK       Y OF TASK | TASK TITLE       % OF TASK       10       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14       11       12       13       14 | TASK TTLE       % of TASK       Ti         Analysis of The State of Art in Trubulent Spray Exportation       0\$ <td< td=""></td<> |

MODELLING SPRAY DYNAMICS FOR EVAPORATION AND COMBUSTION - Jietuo WANG (STASA)





# Thank you for your attention!

MODELLING SPRAY DYNAMICS FOR EVAPORATION AND COMBUSTION - Jietuo WANG (STASA) 12