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P1. De Gregorio F., Reliability study of a color PIV for large industrial facility, <i>CIRA</i> , <i>pp 205-216.</i>	
P2. Veerman H.P., PIV measurements in presence of a large out of plane component, <i>NLR, pp 217-225.</i>	
P3. Monnier J.C., Gilliot A., Croisier G., Characterisation of the EUROPiV nozzle by PIV, using a CCD recording device, <i>ONERA-DAAP, pp 226-233.</i>	
P4. Lecuona A., Ruiz-Rivas U., Rodriguez P.A., Nogueira J.I., Study of PIV measurements stability and convergence, <i>Madrid University, pp 234-251.</i>	
P5. Royer H. *, Monnier J.C. **, Croisier G. **, Holographic PIV at a long distance, <i>ISL* and ONERA/IMFL**, pp 252-258.</i>	

- P6. Allano D. *, Fournel T.**, Royer H. ***, Lecerf A. *, Riou L. **, Chauvelon M. **, Joint PIV recording by three different methods for absolute comparisons of the velocity maps, *Rouen* and St Etienne***, *Universities and ISL****, pp 259-266.
- P7. Monnier J.C. *, Croisier G*, Stanislas** M., Analysis of the synthetic image 9 from the Europiv database, *ONERA-DAAP**, *LML***, pp 267-278.
- P8. Udrea* D.D., Bryanston-Cross P.J. *, M. Moroni **, Querzoli G. ***, Particle Tracking Velocimetry Techniques., *Warwick**, *Rome***, *Italy****, *Universities*, pp 279-304.
- P9. Cenedese A., Espa S., Pocecco A., The influence of the velocity component normal to the observation plane in PIV and PTV, *Rome University*, pp 305-312.
- P10. Allano D., Trinité M., Sub-pixel accuracy for displacements of less than one pixel, and estimation of a signal to noise ratio (quality factor) in the correlation plane, *Rouen University*, pp 313-321.
- P11. Fournel T., Chauvelon M., Riou L., Fayolle J., Ducottet C., Schon J.P., Identification and Cepstrum compared to correlation in PIV, *St Etienne University*, pp 322-331.
- P12. Lecuona A., Nogueira J.I., Rodriguez P.A., Ruiz-Rivas U., PIV data post processing : data validation, interpolation and vorticity calculation, *Madrid University*, pp 332-355.
- P13. Bardera R. , Scholz D , Particle images quality in photographic PIV, *INTA*, pp 356-363.
- P14. Veerman H.P. *, Den Boer R.J.W. *, Westerweel J. **, PIV seeding for high-speed applications with low wind-tunnel pollution, *NLR* and Delft University***, pp 364-376.
- P15. Sjörs K., Seeding of the FFA 3.6 m low speed wind tunnel with consideration for occupational hygiene, *FFA*, pp 377-383.
- P16. Borleteau J.P., Seeding in a large quiet water tank for the study of a wake flow with PIV techniques, *SIREHNA*, pp 384-390.
- P17. Stanislas M., Foucaut J.M., Dupont P., Carlier J., Comparison between Film and CCD Recording of PIV Images using a photographic camera, *LML*, pp 391-407.
- P18. Cenedese A., Pocecco A., Development of a system based on different colour laser light pulses, *Rome University*, pp 408-417.
- P19. Zara H., Jay J., Fouquet R., Riou L., Jacquet G., Fisher V., Study of fast flows illuminated by a continuous Laser using two intensified cameras and a synchronization system, *St Etienne University*, pp 418-428.

- P20. Cenedese A., De Gregorio F., Pocecco A., Querzoli G., Effects of Images Compression on PIV and PTV Analysis, *Rome University*, pp 429-438.
- P21. Lecerf A., Trinité M., Stereoscopic PIV : Translation Method, *Université de Rouen*, pp 439-458.
- P22. Westerweel J., Van Oord J, Stereoscopic PIV Measurements in a Turbulent Boundary Layer, *Delft, angular method*, pp. 459-478.
- P23. Udrea D.D. et al, Three-Component Particle Image Velocimetry by Defocusing, *Warwick University*, pp 479-494.
- P24. Hinrichs H., Hinsch K.D., Netter R., Surmann C., Light-in-Flight Particle Holography, *Ossietzky Universität Oldenburg*, pp 495-501.
- P25. Fabry E.P., Sieverding C.H., 3D Stereoscopic Holographic PIV in Swirling Flows and Turbomachine Cascades, *V.K.I.*, pp 502-523.

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