1) Molecular Polarizability - an Introduction

- When a beam of light is incident on a transparent material medium of refractive index different from that of its surroundings, the medium gets polarized.
- If a light wave of electric intensity $\vec{E}$ goes through a molecule in the medium, it induces an optic moment in the molecule. The molecule is said to be polarized.
- Theoretically; therefore, polarizability should be a function of the incident light frequency.
- α can be regarded as a constant; unless, when measuring n.
- $\boldsymbol{P} = \alpha \boldsymbol{E}$, $\boldsymbol{P}$ is the dipole moment, $\boldsymbol{E}$ is the electric field, α is the polarizability of the molecule.
- In isotropic materials α can be treated as a scalar of constant magnitude.
- If the material is anisotropic, the polarizability acquires directional property.
- For optically inactive molecules, α is a symmetrical tensor.
- An optically active molecule, rotates the plane of polarization after it goes through the molecule. Dextorotatory component rotates the light clockwise, and Levorotatory components rotates the light counterclockwise.
- The mean molecular polarizability is given by: $\alpha = \dfrac{2}{3}\left(b_{_L} + b_{_T} + b_{_V}\right)$. Where $b_{_L}$ is the longitudinal link polarizability, $b_{_T}$ is the link polarizability in the plane of the molecule or group containing the link and at right angles to it and $b_{_V}$ is the one normal to the plane.
- Individual chemical bonds can be associated with polarizability components along their lengths.

Bibliography

[1] Meng Wang, Ali Mani, and Stanislav Gordeyev. “Physics and Computation of Aero-Optics”. In: *Annual Review of Fluid Mechanics* 44 (2012), pp. 299–321.

[2] Albina Tropina et al. “Aero-optical effects in non-equilibrium air”. In: *2018 Plasmadynamics and Lasers Conference*. Atlanta, Georgia: AIAA Paper 2018-3904, June 2018.

[3] Christopher M. Wyckham and Alexander J. Smits. “Aero-Optic Distortion in Transonic and Hypersonic Turbulent Boundary Layers”. In: *AIAA Journal* 47.9 (Sept. 2009), pp. 2158–2168.

[4] Konstantinos Vogiatzis et al. “HyperCode: A framework for high-order accurate turbulent non-equilibrium hypersonic flow simulations”. In: *AIAA Scitech 2020 Forum*. Orlando, FL: AIAA 2020-2192, Jan. 2020.

[5] John S. Pazder, Konstantinos Vogiatzis, and George Z. Angeli. “Dome and mirror seeing estimates for the Thirty Meter Telescope”. In: *Modeling, Systems Engineering, and Project Management for Astronomy III*. Vol. 7017. Marseille, France: SPIE, July 2008, pp. 229–237.

[6] Konstantinos Vogiatzis, Eswar Josyula, and Prakash Vedula. “Role of High Fidelity Nonequilibrium Modeling in Laminar and Turbulent Flows for High Speed ISR Missions”. In: *46th AIAA Thermophysics Conference*. Washington, D.C.: AIAA Paper 2016-4317, June 2016.

[7] Konstantinos Vogiatzis et al. “Aero-thermal simulations of the TMT Laser Guide Star Facility”. In: *Adaptive Optics Systems IV*. Ed. by Enrico Marchetti, Laird M. Close, and Jean-Pierre Véran. Vol. 9148. International Society for Optics and Photonics. Montreal, Quebec: SPIE, Aug. 2014, pp. 2024–2033.

[8] Anubhav Gupta and Brian Argrow. “Analytical Approach for Aero-Optical and Atmospheric Effects in Supersonic Flow Fields”. In: *AIAA Scitech 2020 Forum*. Orlando, FL: AIAA Paper 2020-0684, Jan. 2020.

[9] Offer Pade, Evgeny Frumker, and Paula Ines Rojt. “Optical distortions caused by propagation through turbulent shear layers”. In: *Optics in Atmospheric Propagation and Adaptive Systems VI*. Ed. by John D. Gonglewski and Karin Stein. Vol. 5237. International Society for Optics and Photonics. Barcelona, Spain: SPIE, Feb. 2004, pp. 31–38.

[10] Madhusudhan Kundrapu et al. “Modeling Radio Communication Blackout and Blackout Mitigation in Hypersonic Vehicles”. In: *Journal of Spacecraft and Rockets* 52.3 (May 2015), pp. 853–862.

[11] Lauren E. Mackey and Iain D. Boyd. “Assessment of Hypersonic Flow Physics on Aero-Optics”. In: *AIAA Journal* 57.9 (Sept. 2019), pp. 3885–3897.

[12] Albina A Tropina et al. “Influence of vibrational non-equilibrium on the polarizability and refraction index in air: computational study”. In: *Journal of Physics D: Applied Physics* 53.10 (Dec. 2019), p. 105201.

[13] Sebastian Karl, Jan Martinez Schramm, and Klaus Hannemann. “High Enthalpy Cylinder Flow in HEG: A Basis for CFD Validation”. In: *33rd AIAA Fluid Dynamics Conference and Exhibit*. Orlando, FL: AIAA Paper 2003-4252, June 2003.

[14] J. H. B. Anderson. “Experimental Determination of the Gladstone-Dale Constants for Dissociating Oxygen”. In: *The Physics of Fluids* 12.5 (1969), pp. I-57-I–60.

[15] Ralph A. Alpher and Donald R. White. “Optical Refractivity of High-Temperature Gases. I. Effects Resulting from Dissociation of Diatomic Gases”. In: *The Physics of Fluids* 2.2 (Mar. 1959), pp. 153–161.

[16] Xiao Qin et al. “Effect of varying composition on temperature reconstructions obtained from refractive index measurements in flames”. In: *Combustion and Flame* 128.1 (2002), pp. 121–132.

[17] John Siegenthaler, Eric Jumper, and Stanislav Gordeyev. "Atmospheric Propagation vs. Aero-Optics". In: *46th AIAA Aerospace Sciences Meeting and Exhibit*. Reno, Nevada: AIAA 2008-1076, Jan. 2008.

[18] Wei Ren and Hong Liu. "Study on the Effect of Compressibility and Knudsen Number on Aero Optics in Supersonic/Hypersonic Flows". In: *42nd AIAA Fluid Dynamics Conference and Exhibit*. New Orleans, Louisiana: AIAA Paper 2012-2988, June 2012.