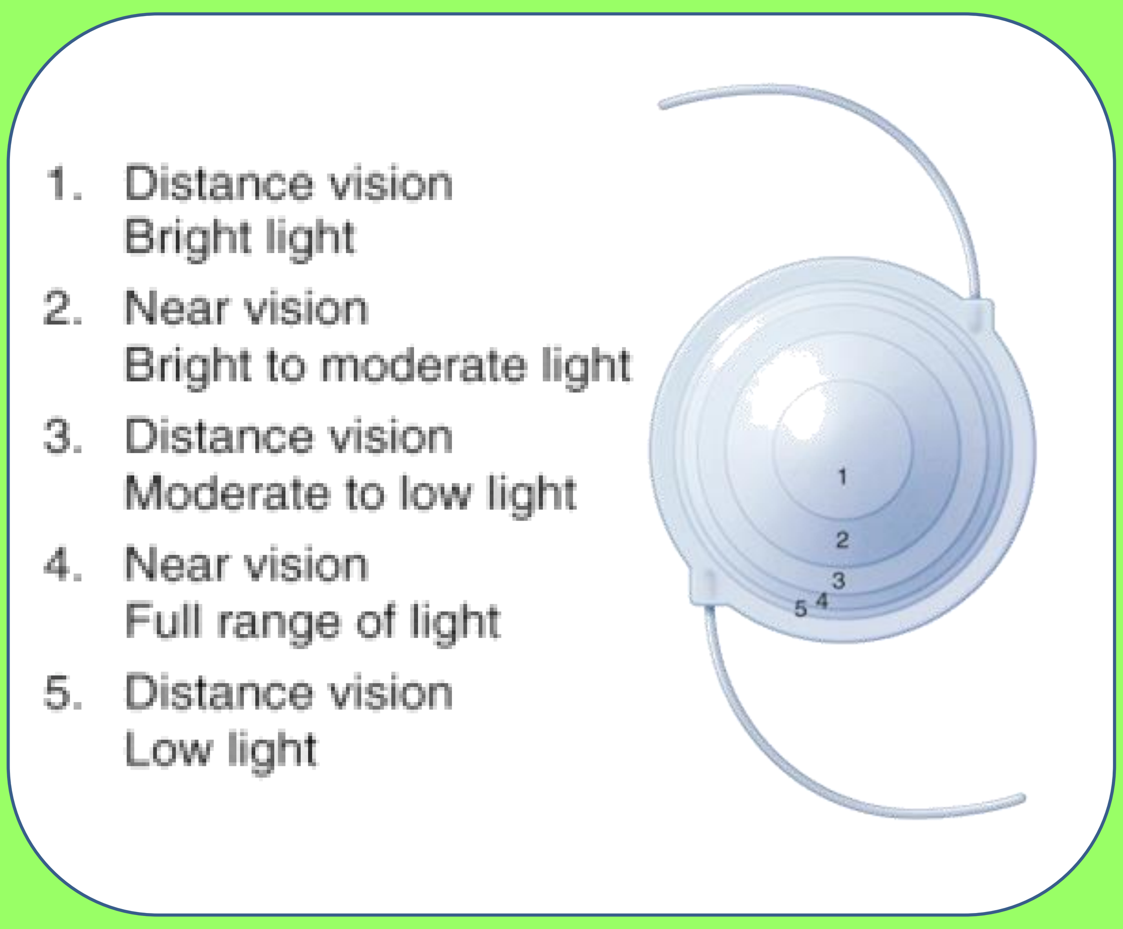
Stray Light comparison of four different Accommodative Intra-Ocular Lens (AIOL) Designs

Eli Weinberg and David Sinefeld

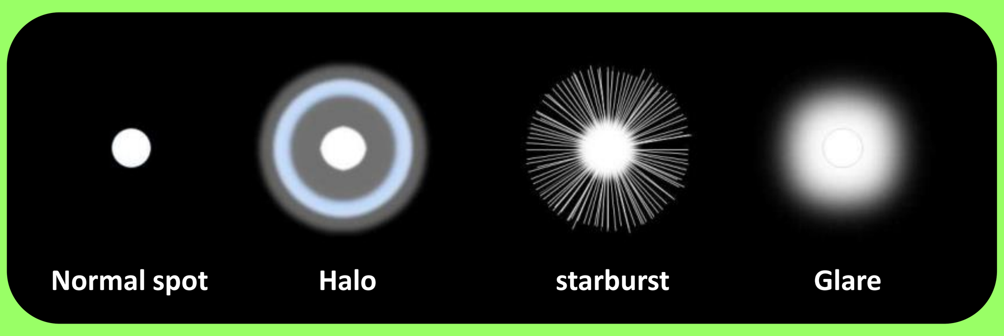
Applied Physics and Electro-Optical engineering department, Jerusalem College of Technology, Israel

We reconstruct optical models of four different AIOL concepts, and use them to simulate their expected stray light patterns on the retina, respectively. This comparative analysis of AIOL stray light allows us to identify the mechanical characteristics that produce IOL dysphotopsia, and to offer insights on how to reduce the severity of this phenomenon among cataract patients.

Dysphotopsia due to Multifocal IOL

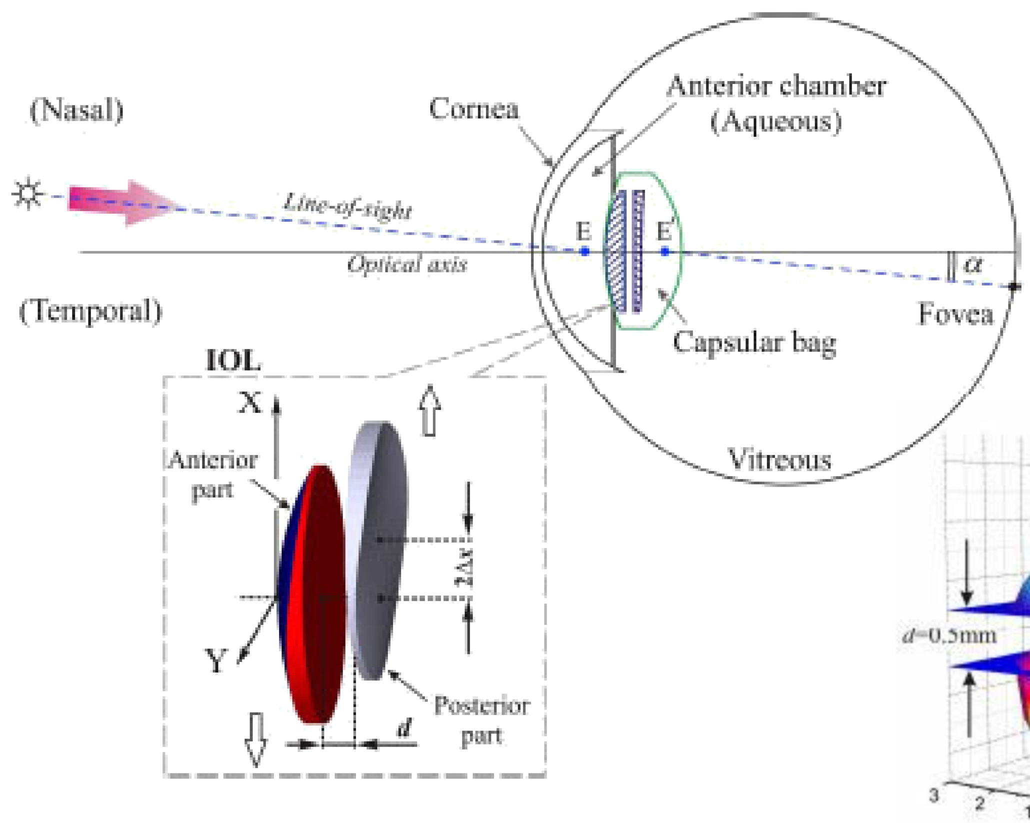


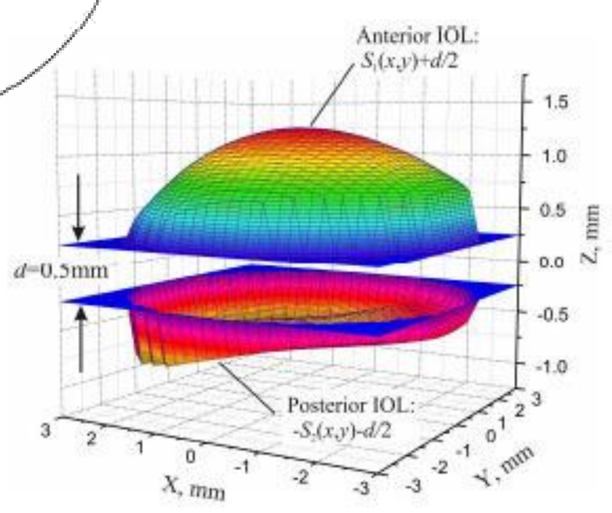
- MF-IOLs suffer from pronounced glare
- Night time vision discomfort
- Degraded visual acuity in intermediate range
- AIOLs maintain good focus for all distances



Reconstruction of AIOL designs

Dual-optic lens based on Alvarez principle – sideways motion between lenses causes focal accommodation

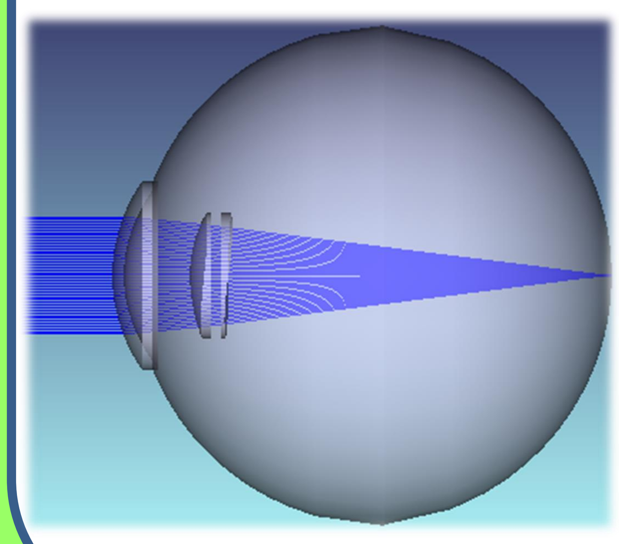


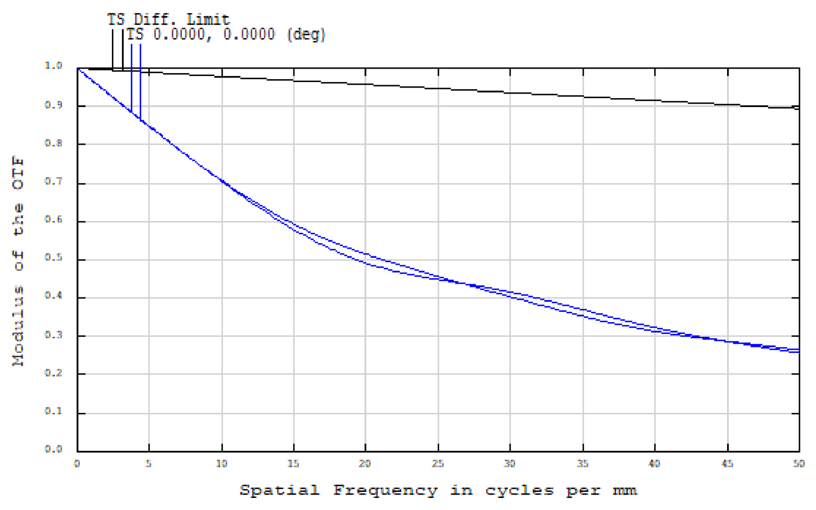


Sag Formulae – can be expanded to fit extended polynomial format:

$$z = S_1(x, y) = h_1 - A_1\left(xy^2 + \frac{x^3}{3}\right) - \frac{r^2}{R\left\{1 + \sqrt{1 - \left(\frac{r}{R}\right)^2}\right\}} + a_1 r^4 + a_2 r^6,$$

$$z = S_2(x, y) = h_2 + A_2\left(xy^2 + \frac{x^3}{3}\right),$$

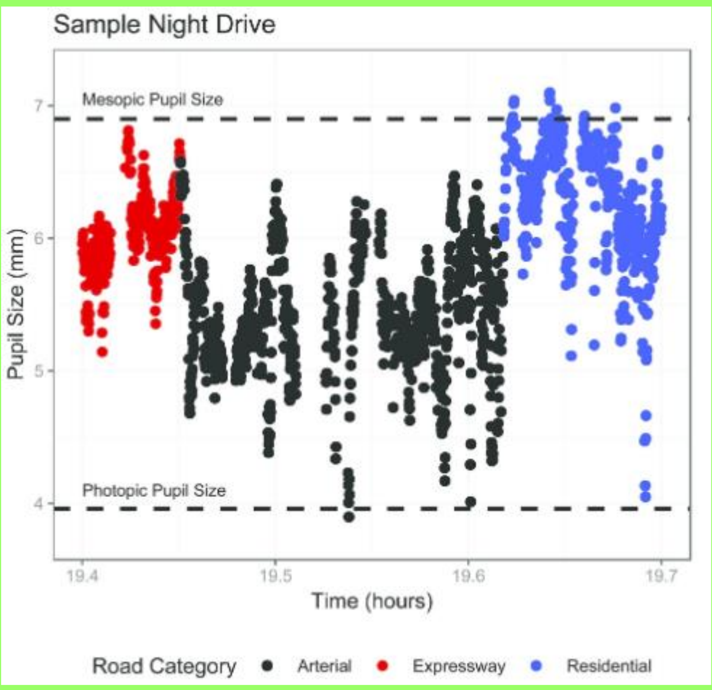




Good MTF results over near-far distance range

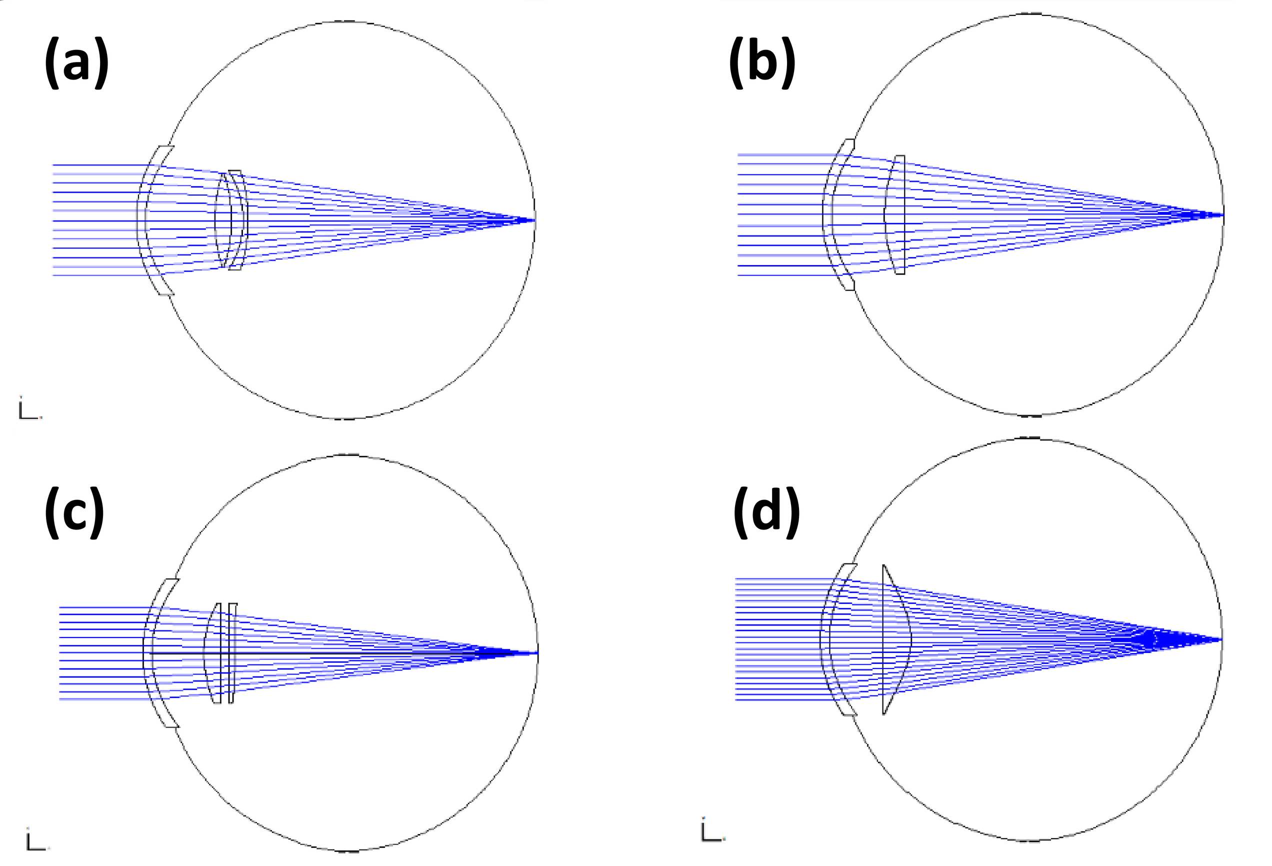
Pupil Size during Night-time Driving

- Average pupil size on dark road is 5.6mm.
- Standard of deviation is ±1mm.
- Stray light modelling used 6.5mm.



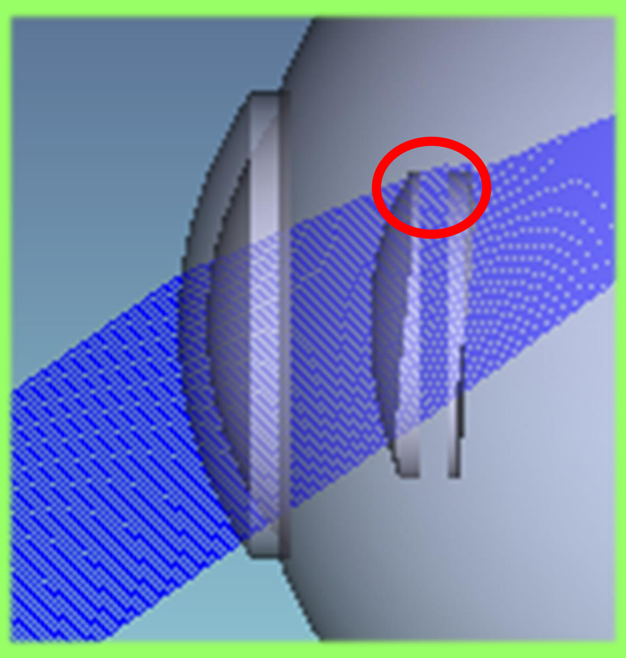
Alex A Black; Joanne M Wood; Michael J Collins; Gillian Isoardi. "Variations in pupil size and light levels while driving at night", *Investigative Ophthalmology & Visual Science*, July 2019, Vol.60, 5929..

4 AIOL designs modelled in-situ



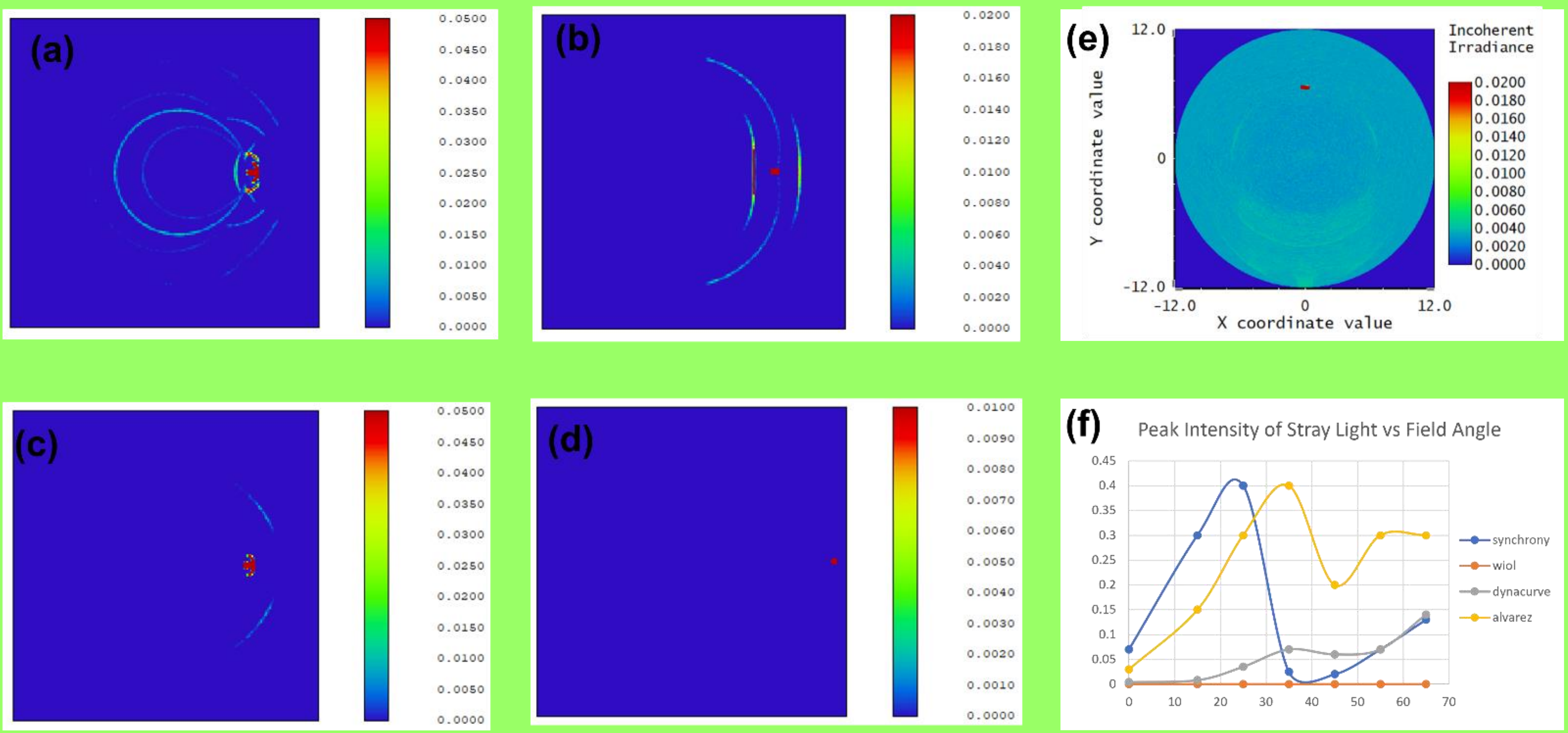
- **(a) synchrony dual-optic based on inter-optic distance adjustment.**
- **(b) dynacurve based on adjustable lens curvature.**
- **(c) lumina based on alvarez principle.**
- **(d) WIOL based on adjustable lens curvature with a hyperbolic surface profile.**

Stray Light Sources in AIOLs



- **Proximity of IOL edge to beam path – problematic at larger field angles**
- **Proximity of IOL edge to plane of pupil – problematic for multiple-optic designs**

Results: Retinal Stray Light Artifacts



- **(a-d) Retinal intensity maps of ghost analysis at 25º FOV.**
- **(e) Retinal intensity map of phakic eye at 25º FOV produced in non-sequential modelling;**
- **(f) summary graph of SL peak intensity per FOV for all 4 AIOL concepts.**