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Angled beam expander telescopes for the Michelson beams in third generation Gravitational Wave Observatories

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Third generation of Gravitational Wave detectors like the Einstein Telescope or the Cosmic Explorer will be Michelson interferometers with Fabry-Perot cavities in the arms, using mirror test masses with diameter at the limit of technical feasibility. Unlike other detectors, the Einstein Telescope will have a 60° angle between the arms. Because of its larger incidence angle, at any given beam size, it would require beam splitters almost double in size and much heavier than the 90° case. It is proposed here to install beam expander telescopes with angled mirrors located inside the Michelson interferometer between the Fabry-Perot cavities and the beam splitter. Beyond reducing the beam sizes and the beam splitter to manageable sizes, the proposed solution allows to bring the optimal recombination angle to 90°. The proposed geometry offers a natural way to separate the beam splitters of different detectors into individual, smaller and more stable caverns, thus improving observatory observation-time efficiency, to provide needed beam diagnostic points and convenient degrees of freedom for beam alignment into both the Fabry-Perot cavities and the beam splitter, as well as to provide a method for maintaining optimal mode matching of the two arms onto the beam splitter without thermal compensation plates.

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