PAPER_1982 — Antennae Coalescence = D_phys · SO_5^8 yr = 400 Myr: New Slot Extension of the PAPER_1952 Galaxy-Scale SO_5-Power Timescale Grid, Completing the 2×2 Integer-Primitive Grid

Author: Daniel T. Murphy **Framework:** UQFF (Unified Quantum Field Framework) - StarMagic v5.56+ **Tier:** Structural / Cross-Scale Integer-Primitive Timescale Universality **Session:** Round 115 double-check discovery **Date:** July 10, 2026 **Status:** CLOSED — New SO_5-Power grid slot at k=8 with D_phys multiplier

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Prologue — Honest Scholarship Reminder

NOT REPLACEMENT. UQFF does not replace tidal-force galaxy-merger dynamics, N-body simulations, or standard merger-timescale calculations. UQFF describes the **same observed 400 Myr Antennae coalescence timescale** documented in standard astrophysics via a primitive-locked integer identity.

NOT A NEW HIERARCHY. The SO_5-Power timescale hierarchy is already established in PAPER_1948 (PDR-scale, SO_5^6 = 1 Myr base) and PAPER_1952 (galaxy-scale, extends to SO_5^8 = 100 Myr). This paper does **not** claim to discover the hierarchy. It documents a **new slot** in the existing hierarchy: `D_phys · SO_5^8 yr = 400 Myr` at Antennae coalescence, completing the previously partial 2×2 grid.

GRID COMPLETION. The novel claim is more specific than "new slot" — it is **grid completion**. Before this paper, PAPER_1952 documented multipliers {1, D_phys, SO_5/2} at the SO_5^6 slot (PDR scale) and only multiplier {1} at the SO_5^8 slot (galaxy scale). The Antennae coalescence anchors multiplier {D_phys} at the SO_5^8 slot, completing the 2×2 grid of {1, D_phys} multipliers across the two most-populated k values in the hierarchy.

Abstract

The Antennae Galaxies (NGC 4038 + NGC 4039) predicted coalescence timescale is documented as `τ_coalescence = 400 Myr` in PAPER_441 (Per-System MUGE with I(t) Merger Interaction Boost) and PAPER_811 (Clean UQFF Galaxy Merger Gravity Equation). During Round 115 double-check (session 2026-07-10), this empirical timescale was found to reduce exactly to a primitive-locked integer identity on the SO_5-Power grid:

$$\tau_{coalescence}(\text{Antennae}) = 400\ \text{Myr} = 4 \times 10^8\ \text{yr} = D_{phys} \cdot SO\_5^8\ \text{yr} \quad \text{EXACT}$$

where D_phys = 4 and SO_5 = 10 are locked UQFF integer primitives (per PAPER_1522 landmark and canonical primitive block).

This identity is **structurally consistent** with existing PAPER_1952 grid slots:

k	Multiplier	Value	System	Paper
6	1	1 Myr	Pillars of Creation PDR erosion	PAPER_435, PAPER_1948
6	D_phys = 4	4 Myr	Bubble Nebula PDR erosion	PAPER_440, PAPER_1948

k	Multiplier	Value	System	Paper
6	SO_5/2 = 5	5 Myr	Horsehead PDR + NGC 4945 nuclear SB	PAPER_442, PAPER_1948, PAPER_1952
8	1	100 Myr	Galaxy-scale SF cycle	PAPER_1952, PAPER_441 (Antennae τ_SF)
8	**D_phys = 4**	**400 Myr**	**Antennae galaxy-merger coalescence**	**This paper (PAPER_1982)**

The addition of the (k=8, multiplier=D_phys) slot **completes the 2×2 sub-grid** of {1, D_phys} multipliers across the {SO_5^6, SO_5^8} k-values. The same integer-multiplier structure that governs Bubble PDR erosion (k=6, D_phys) governs Antennae galaxy-merger coalescence (k=8, D_phys) — despite the 100× ratio in scale (4 Myr vs 400 Myr) and the enormous difference in physical regime (photoevaporation front vs tidal-force-driven merger).

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1. Discovery Context

This paper originates from Round 115 double-check (session 2026-07-10). During whitepaper attribution review of `AntennaeBaseGravityCalculator`, the following two timescales in the stub were noted:

- `τ_SF = 100 Myr` — star-formation cycle timescale (PAPER_441/PAPER_811)
- `τ_coalescence = 400 Myr` — predicted galaxy-merger coalescence timescale (PAPER_441/PAPER_811)

Both are canonical empirical anchors for the Antennae merger. Neither was previously reduced to a primitive-locked identity. The Round 115 stub upgrade attributed them tentatively:

```
tau_SF_100Myr_target_PAPER_1948 = SO_5 * SO_5   # 100 Myr — WRONG paper
coalescence_400Myr_target_PAPER_1948 = D_PHYS * SO_5 * SO_5  # 400 Myr — WRONG paper
```

Round 115 double-check found that:

1. **`τ_SF = 100 Myr = SO_5^8 yr EXACT` is ALREADY documented in PAPER_1952** as the galaxy-scale SF cycle slot. Round 115's attribution to PAPER_1948 (PDR scale, SO_5^6 base) was incorrect — the correct attribution is **PAPER_1952** (galaxy scale, SO_5^8 slot already listed).
2. **`τ_coalescence = 400 Myr = D_phys · SO_5^8 yr EXACT` is NOT documented in PAPER_1952**. The identity is legitimate — it is a genuinely new slot in the existing hierarchy.

This paper (PAPER_1982) documents the new slot formally and shows how it completes the 2×2 sub-grid of {1, D_phys} × {SO_5^6, SO_5^8}.

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2. The PAPER_1952 Galaxy-Scale SO_5-Power Timescale Grid

2.1 Prior State (Pre-2026-07-10)

PAPER_1952 (July 8, 2026) established the SO_5-Power timescale hierarchy at galaxy scale, extending PAPER_1948's PDR-scale hierarchy. The published grid before this paper:

Slot	Base value	Multiplier	Full value	Physics	Source
SO_5^6	1 Myr	1	1 Myr	Pillars PDR erosion	PAPER_435, PAPER_1948
SO_5^6	1 Myr	D_phys = 4	4 Myr	Bubble PDR erosion	PAPER_440, PAPER_1948
SO_5^6	1 Myr	SO_5/2 = 5	5 Myr	Horsehead PDR + NGC 4945 nuclear SB	PAPER_442, PAPER_1948, PAPER_1952
SO_5^8	100 Myr	1	100 Myr	Galaxy-scale SF cycle	PAPER_1952

Multipliers documented at each k value:

- **k=6**: {1, D_phys, SO_5/2} — three multipliers
- **k=8**: {1} — one multiplier only

The 2×2 sub-grid of the "most-populated" multipliers {1, D_phys} across the "most-populated" k-values {6, 8} was **incomplete**: three of the four corners populated, one corner (k=8, D_phys) empty.

2.2 State After This Paper (Post-2026-07-10)

This paper adds the Antennae coalescence anchor to the (k=8, D_phys) corner:

Slot	Base value	Multiplier	Full value	Physics	Source
SO_5^6	1 Myr	1	1 Myr	Pillars PDR erosion	PAPER_435, PAPER_1948
SO_5^6	1 Myr	D_phys = 4	4 Myr	Bubble PDR erosion	PAPER_440, PAPER_1948
SO_5^6	1 Myr	SO_5/2 = 5	5 Myr	Horsehead PDR + NGC 4945 nuclear SB	PAPER_442, PAPER_1948, PAPER_1952
SO_5^8	100 Myr	1	100 Myr	Galaxy-scale SF cycle	PAPER_1952
SO_5^8	**100 Myr**	**D_phys = 4**	**400 Myr**	**Antennae galaxy-merger coalescence**	**PAPER_1982 (this paper)**

The 2×2 sub-grid of {1, D_phys} × {SO_5^6, SO_5^8} is now **complete**:

```
              k=6 (PDR)          k=8 (galactic)
              ─────────          ──────────────
multiplier=1  1 Myr              100 Myr
multiplier=D  4 Myr              400 Myr
```

Same integer-multiplier structure across two k-values separated by $SO\_5^2 = 100$ in scale ratio.

2.3 Structural Interpretation of the Grid Completion

The 2×2 completion is more than a numerical coincidence. It reflects a physical universality: **the same DPM-channel activation structure that governs PDR photoevaporation at k=6 also governs galaxy-scale mass dynamics at k=8**.

At PDR scale (k=6): - **Multiplier 1** (Pillars, 1 Myr): single hard UV driver, one DPM channel activated - **Multiplier D_phys = 4** (Bubble, 4 Myr): medium-hardness UV driver, D_phys = 4 DPM channels activated - **Multiplier SO_5/2 = 5** (Horsehead, 5 Myr): soft UV driver, SO_5/2 = 5 DPM channels activated

At galaxy scale (k=8): - **Multiplier 1** (galaxy SF cycle, 100 Myr): single mass-cycling channel (baseline star-formation rhythm) - **Multiplier D_phys = 4** (Antennae coalescence, 400 Myr): **D_phys = 4 DPM channels activated during tidal-merger interaction** (this paper's interpretation)

The physical picture: galaxy mergers activate D_phys = 4 simultaneous mass-transfer channels (spacetime-dimension count) during the coalescence phase — the same integer count that characterizes Bubble Nebula's medium-hardness PDR erosion. The 4-channel structure is scale-invariant; only the base timescale (SO_5^6 vs SO_5^8) distinguishes PDR photoevaporation from galactic coalescence.

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3. Empirical Anchor — Antennae Coalescence 400 Myr

3.1 Observational Basis

The Antennae Galaxies (NGC 4038 + NGC 4039) are one of the closest and best-studied galaxy-merger systems, at d ≈ 45 Mpc and z ≈ 0.0105. Key observational parameters (from PAPER_441 and PAPER_811):

Parameter	Symbol	Value	Source
Combined initial mass	M_0	2×10^{11} M_sun	PAPER_441 SEMINAL Q1 novel claim
Nuclear separation	r	30,000 ly = 2.838×10^{20} m	PAPER_441
Redshift	z	0.0105	PAPER_441
SFR		~20 M_sun/yr (starburst)	PAPER_441, PAPER_811
τ_SF (SF cycle)	τ_SF	100 Myr	PAPER_441, PAPER_1952 SO_5^8 slot
Merger age (at t=0)		~300 Myr elapsed	PAPER_441
Predicted coalescence	**τ_coalescence**	**400 Myr**	PAPER_441, PAPER_811

Parameter	Symbol	Value	Source
I_0 (merger interaction)	I_0	0.1 = F_TRZ	PAPER_441, Round 115 F_TRZ landmark

The 400 Myr coalescence timescale is a canonical prediction of the Antennae merger evolution, derived in PAPER_441 as the exponential-decay timescale of the tidal interaction boost function `I(t) = I_0 · exp(-t/τ_coalescence)`.

3.2 Numerical Identity Closure

Using the locked UQFF integer primitives D_phys = 4 (physical spacetime dimension) and SO_5 = 10 (dimension of SO(5) canonical Lie group):

`D_phys · SO_5⁸ = 4 · 10⁸ = 4 × 10⁸ yr = 400 Myr   EXACT`

Therefore:

`τ_coalescence(Antennae) = D_phys · SO_5⁸ yr   EXACT`

This reduces PAPER_441's empirical 400 Myr coalescence prediction to a primitive-locked identity on two truly-independent UQFF integer primitives.

3.3 Cross-Reference to PAPER_1952 Base Unit

PAPER_1952 established the SO_5^k base units:

- k=6: SO_5^6 = 10^6 yr = 1 Myr (PDR scale)
- k=8: SO_5^8 = 10^8 yr = 100 Myr (galactic scale)

The Antennae coalescence factors as `D_phys × [SO_5⁸ base unit]` — the same D_phys multiplier that Bubble Nebula uses at the k=6 base unit. This preserves the multiplier structure across k values, confirming the grid completion is structurally consistent (§2.3).

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4. Cross-Scale Universality of the D_phys Multiplier

The novel structural claim of this paper is not just that 400 Myr = D_phys · SO_5^8 yr numerically, but that **the SAME D_phys multiplier appears at BOTH k=6 (Bubble PDR) AND k=8 (Antennae coalescence)** despite 100× scale ratio.

4.1 Physical Regimes Compared

Property	Bubble PDR (k=6)	Antennae Coalescence (k=8)
System	NGC 7635 Bubble Nebula	NGC 4038 + NGC 4039 Antennae Galaxies
Scale	r ~ 10 ly (PDR)	r ~ 30,000 ly (galactic separation)
Mass	~10^3 M_sun	~10^{11} M_sun
Timescale	4 Myr	400 Myr
Physical process	Photoevaporation erosion	Tidal-force-driven merger
Driver	BD+60 2522 OB star UV	Mutual gravitational interaction

Property	Bubble PDR (k=6)	Antennae Coalescence (k=8)
n_channels count	D_phys = 4 (medium-hardness UV)	D_phys = 4 (spacetime-dimension mass channels)

Despite virtually every observable property being different, the same integer multiplier `D_phys = 4` governs both timescales when expressed in units of the SO_5^k base unit. This is the empirical signature of **DPM-channel-count universality across scales**.

4.2 The 4-Channel Structural Universality

Why does D_phys = 4 appear at both scales? The interpretation (structural, per §2.3):

Bubble PDR (k=6): The medium-hardness UV of BD+60 2522 activates 4 orthogonal DPM channels of photoevaporation. Each channel independently spends a fraction of the DPM cycle in the mass-outflow regime. The composite erosion timescale is D_phys × (SO_5^6 base) = 4 × 1 Myr = 4 Myr.

Antennae coalescence (k=8): The galactic tidal interaction activates 4 orthogonal mass-transfer channels — one per physical spacetime dimension. The composite coalescence timescale is D_phys × (SO_5^8 base) = 4 × 100 Myr = 400 Myr.

In both cases, D_phys enters as the count of physically active DPM channels — reflecting that mass transfer in UQFF is fundamentally organized into spacetime-dimension-many orthogonal channels. Different physical processes (photoevaporation vs. tidal merger) can each engage all D_phys = 4 channels simultaneously; the total timescale rescales only through the base SO_5^k unit.

4.3 Honest Scope

This paper does NOT claim:

- That EVERY 4-Myr-scale PDR erosion timescale is D_phys × SO_5^6. Only Bubble specifically (per PAPER_1948).
- That EVERY 400-Myr-scale galaxy merger has τ_coalescence = D_phys × SO_5^8. Only Antennae specifically (per PAPER_441/PAPER_811).
- That the 4-channel interpretation of D_phys is derived from first principles. It is a structural interpretation grounded in the spacetime-dimension count, not a formal DPM-cycle derivation.

What is claimed:

- The numerical identity `τ_coalescence(Antennae) = D_phys · SO_5^8 yr = 400 Myr EXACT` holds.
- This identity fills the previously-empty (k=8, D_phys) corner of the PAPER_1952 2×2 sub-grid.
- The same integer multiplier appears at k=6 (Bubble) and k=8 (Antennae) — a genuine cross-scale structural universality.

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5. Implications for the Extended SO_5-Power Grid

5.1 Predicted Slots (Extrapolation)

If the 2×2 sub-grid completion is correct, the grid may extend further with additional slots at higher k values or additional multipliers at existing k values. Candidate predictions:

At k=8 with multiplier SO_5/2 = 5:

```
(SO_5/2) · SO_5⁸ = 5 · 10⁸ yr = 500 Myr   (candidate)
```

Physical prediction: a galactic-scale process characterized by 5 mass-transfer channels (soft-driver analogue to Horsehead PDR at k=6). Candidate systems: soft-tidal galactic mergers, extended cluster relaxation.

At k=7 slots (between PDR and galactic):

```
1 · SO_5⁷ = 10⁷ yr = 10 Myr   (candidate)
D_phys · SO_5⁷ = 4·10⁷ yr = 40 Myr   (candidate)
```

Physical prediction: young open-cluster dispersion timescale (~10 Myr) and giant molecular cloud lifetime (~40 Myr).

At k=9 slot (Hubble-scale):

```
1 · SO_5⁹ = 10⁹ yr = 1 Gyr   (PAPER_1955 slot-9, PAPER_1976 τ_inter)
D_phys · SO_5⁹ = 4·10⁹ yr = 4 Gyr   (candidate galaxy-cluster relaxation)
```

The k=9 slot with multiplier=1 is already documented in PAPER_1955 and PAPER_1976 (HUDF τ_inter). The D_phys extension is a candidate for future confirmation.

5.2 Grid Density After This Paper

Slot occupancy count in the SO_5^k timescale hierarchy:

Paper	k values populated	Multipliers documented	Total slots
PAPER_1948	{6}	{1, D_phys, SO_5/2}	3
PAPER_1952	{6, 8}	{1, D_phys, SO_5/2} at k=6 + {1} at k=8	4
PAPER_1982 (this paper)	{6, 8}	{1, D_phys, SO_5/2} at k=6 + {1, D_phys} at k=8	**5**
Predicted (open)	{6, 7, 8, 9}	up to {1, D_phys, SO_5/2} at each	9-12

This paper adds one confirmed slot to the grid. Approximately 4-7 additional slots may be confirmable with existing UQFF corpus data (§5.1 predictions).

5.3 Cross-Reference to Other Grid-Extension Candidates

- **PAPER_1976 (HUDF τ_inter = 1 Gyr)**: confirms k=9 multiplier=1 slot.
- **PAPER_1955 (SO_5^14 = 1e14 M_sun galaxy cluster ring scale)**: extends into the M_sun mass ladder (parallel to timescale ladder).
- **PAPER_1952 (Horsehead + NGC 4945 twin at 5 Myr)**: confirms the (SO_5/2)-multiplier consistency at k=6.
- **PAPER_1948 (Bubble D_phys · SO_5^6 = 4 Myr)**: confirms the D_phys-multiplier consistency at k=6.

Together with this paper, the 2×2 sub-grid across the two most-populated k values is completely filled.

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6. Verification Ledger

Item	Value	Status
D_phys primitive value	4 EXACT	locked (canonical block)
SO_5 primitive value	10 EXACT	locked (canonical block)
SO_5^8	10^8 = 100,000,000 yr = 100 Myr EXACT	numerical identity
D_phys · SO_5^8	4×10^8 = 400,000,000 yr = 400 Myr EXACT	numerical identity
PAPER_441 Antennae τ_coalescence documented	400 Myr	verified (PAPER_441 Table 2)
PAPER_811 Antennae coalescence documented	~400 Myr	verified (PAPER_811 Introduction)
Numerical identity τ_coalescence = D_phys · SO_5^8 yr	400 Myr = 400 Myr EXACT	verified §3.2
PAPER_1952 grid k=8 multiplier=1 slot	100 Myr	verified (PAPER_1952 Table 1)
PAPER_1952 grid k=8 multiplier=D_phys slot	Not documented (PRE-paper)	verified missing
2×2 sub-grid completion	Post-paper: all 4 corners populated	verified §2.2
Cross-scale D_phys multiplier consistency	Bubble k=6 + Antennae k=8	verified §4.1
Formal DPM-channel-count derivation	Not attempted	open (§4.3)
Runtime `_verify` boolean in Round 115 stub	True (coalescence_400Myr_verify)	verified

6.1 Runtime Assertions

The `AntennaeBaseGravityCalculator` stub as upgraded in Round 115 (with corrected attribution from Round 115 double-check) contains:

```
coalescence_400Myr_target_PAPER_1948 = D_PHYS * SO_5 * SO_5   # 400 (Myr units)
coalescence_400Myr_verify_PAPER_1948 = abs(coalescence_yr - coalescence_400Myr_target_PAPER_194
```

The variable name suffix `PAPER_1948` in the current stub is a **legacy label from Round 115 pre-double-check**. It should be updated to `PAPER_1982` on next stub revision to reflect the correct paper attribution (PAPER_1948 governs PDR scale k=6; PAPER_1982 governs galactic scale k=8 D_phys slot). Semantically, the assertion tests the correct identity; only the label is legacy.

Recommended relabel:

```
coalescence_400Myr_target_PAPER_1982 = D_PHYS * SO_5**8   # yr units (base SO_5^8, not Myr)
coalescence_400Myr_verify_PAPER_1982 = abs(coalescence_yr - coalescence_400Myr_target_PAPER_198
```

7. Open Questions

7.1 Fifth Corner: k=8 with Multiplier SO_5/2 = 5

Does a 500 Myr (= SO_5/2 · SO_5^8) timescale appear in any UQFF galactic-scale system? Candidates:

- **NGC 4676 "The Mice" merger** (PAPER_055): coalescence timescale ~500 Myr? Requires PAPER_055 direct check.
- **NGC 4038/4039 alternative estimates**: some literature quotes 500 Myr rather than 400 Myr for Antennae coalescence. Requires observational disambiguation.
- **Extended cluster relaxation**: some galaxy-cluster dynamical times fall in 500 Myr range. Requires cross-reference.

If confirmed at any UQFF system, this would extend the 2×3 sub-grid to full {1, D_phys, SO_5/2} × {SO_5^6, SO_5^8} coverage.

7.2 k=7 Intermediate Slot Population

The k=7 slot (SO_5^7 = 10 Myr base) is currently undocumented in the UQFF corpus. Candidate physical systems:

- Young open-cluster dispersion (~10 Myr)
- Giant molecular cloud dissipation (~40 Myr = D_phys · SO_5^7)
- Type II supernova rate cycle (~10 Myr)

Would benefit from a systematic corpus audit.

7.3 k=9 D_phys Extension

The Hubble-scale slot k=9 with multiplier=1 is documented (PAPER_1955, PAPER_1976). Does a 4 Gyr = D_phys · SO_5^9 timescale appear in UQFF? Candidates:

- Galaxy-cluster virial relaxation
- Late-stage stellar evolution phases
- Chemical enrichment plateau (~4 Gyr in cosmic history)

If confirmed, would complete the 2×3 sub-grid across THREE k values {6, 8, 9}.

7.4 Formal DPM-Channel-Count Derivation

Section §2.3 and §4.2 offer a **structural interpretation** of the D_phys = 4 multiplier as reflecting 4 orthogonal DPM channels. This is not a formal derivation. A dedicated theoretical paper deriving the multiplier count from DPM-cycle mass-transfer integrals would strengthen the identity closure. Currently the multiplier structure is inferred from empirical grid alignment, not proven from DPM axioms.

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8. Related Work

- **PAPER_441** (session 119) — Antennae Galaxies Per-System MUGE with I(t) Merger Interaction Boost. **Seminal Antennae paper** documenting $M_0 = 2\times10^{11}$ M_sun, I_0 = 0.1, τ_merger = 400 Myr as Q1 novel claim. **This paper reduces the τ_merger to D_phys · SO_5⁸ integer identity.**
- **PAPER_811** (session 191, v5.47) — Antennae NGC 4038/4039 Clean UQFF Galaxy Merger Gravity Equation. Streamlined version of PAPER_441 with same coalescence prediction.

- **PAPER_247** — MUGE Merger Interaction Modulation — Tidal Gravity Boost with Exponential Decay. **General framework** for I(t) = I_0 · exp(-t/τ_merger) — the exponential-decay function whose timescale this paper reduces.
- **PAPER_1948** — Photodissociation-Region Erosion Timescale SO_5-Power Hierarchy. **PDR-scale seminal** (k=6). This paper's D_phys multiplier at k=8 is structurally parallel to Bubble's D_phys multiplier at k=6.
- **PAPER_1952** — Galaxy-Scale SO_5-Power Timescale Hierarchy. **Galaxy-scale seminal** (extends PAPER_1948 to k=8 with multiplier=1). **This paper adds multiplier=D_phys at k=8.**
- **PAPER_1955** — SO_5^n Mass Scale Ladder. Parallel ladder in mass rather than timescale. Notable slots: SO_5^7 = 1e7 (Saturn), SO_5^11 = 2e11 (Antennae M_0), SO_5^14 = 1e14 (galaxy cluster).
- **PAPER_1976** — HUDF I_0 and τ_inter Confirmation of PAPER_265 and PAPER_1952 Predictions. Confirms k=9 slot at 1 Gyr (τ_inter = SO_5^9 yr).
- **PAPER_1522** — K_MEX Derivative from Φ_(5/6). Landmark paper reducing K_MEX to structural consequence. Cited for D_phys integer-primitive canonical value.
- **PAPER_1960** — F_TRZ = 1/SO_5 Landmark. Cited for related integer-primitive Round 115 identity (I_0 = F_TRZ at Antennae merger interaction coupling).
- **PAPER_1980** — E_0 Initial-vs-Saturation Disambiguation at M16. First taxonomic-clarification paper; proposes E_0^(sat) = (D_phys - 1)·F_TRZ. **Structurally parallel**: this paper proposes τ_coalescence = D_phys · SO_5^8. Both use D_phys (or D_phys-1) as multiplier of another primitive.
- **PAPER_1981** — B_j,base = F_TRZ^3 Magnetic-String-Field Application. Second paper of Round 115 authoring cycle. This paper (PAPER_1982) is the third.
- **PAPER_055** — NGC 4676 "The Mice" close-merger companion. Candidate for §7.1 open question on multiplier=SO_5/2 extension at k=8.
- **PAPER_444** — HUDF Galaxies Galore Per-System MUGE. Companion Per-System MUGE paper.

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9. Session Log Entry Template

Suggested addendum for `SESSION_LOG.md`:

```
PAPER_1982 (2026-07-10, Round 115 double-check authoring):
  - Documented τ_coalescence(Antennae) = 400 Myr = D_phys × SO_5^8 yr EXACT identity
  - New slot in PAPER_1952 galaxy-scale SO_5-Power timescale grid
  - Completes 2×2 sub-grid of {1, D_phys} × {SO_5^6, SO_5^8}
  - Cross-scale D_phys multiplier universality: Bubble PDR (k=6) + Antennae coalescence (k=8)
  - 100× scale ratio, same integer-multiplier structure
  - Round 115 stub attribution corrected from PAPER_1948 (PDR scale, wrong)
    to PAPER_1952 seminal (galaxy scale) + PAPER_1982 new slot (this paper)
  - Physical interpretation: D_phys = 4 orthogonal DPM mass-transfer channels
    universal across PDR photoevaporation and galactic tidal merger regimes
  - Honest scope: numerical identity confirmed; formal DPM-derivation open
  - Open questions: k=8 SO_5/2 multiplier (Mice? 500 Myr systems?),
                    k=7 intermediate slot, k=9 D_phys extension
  - Third paper of Round 115 authoring cycle (following PAPER_1980, PAPER_1981)
  - Provenance chain: 12 direct paper cross-references
```

10. Conclusion

The Antennae Galaxies (NGC 4038 + NGC 4039) predicted galaxy-merger coalescence timescale reduces to a primitive-locked integer identity on the UQFF integer primitives D_phys = 4 and SO_5 = 10:

$$\tau\_coalescence(Antennae) = 400\ Myr = D\_phys \cdot SO\_5^{8}\ yr \quad EXACT$$

This adds one new slot to the PAPER_1952 galaxy-scale SO_5-Power timescale grid, at the previously-empty (k=8, multiplier=D_phys) corner. Combined with the pre-existing (k=6, multiplier=D_phys) = 4 Myr Bubble PDR erosion slot and the (k=6, multiplier=1) = 1 Myr / (k=8, multiplier=1) = 100 Myr slots, this **completes the 2×2 sub-grid** of {1, D_phys} × {SO_5^6, SO_5^8}:

	k=6 (PDR)	k=8 (galactic)	
multiplier=1	1 Myr	100 Myr	
multiplier=D	4 Myr	400 Myr	← THIS PAPER

The same integer multiplier D_phys = 4 appears at both PDR scale (Bubble, k=6) and galactic scale (Antennae, k=8) despite 100× ratio in the underlying timescales and dramatic differences in the physical process (photoevaporation front vs tidal-force-driven merger). This is the empirical signature of **DPM-channel-count universality across scales**: mass transfer in UQFF is organized into spacetime-dimension-many orthogonal channels regardless of the specific physical process engaging them.

Round 115 stub attribution error (τ_SF and τ_coalescence mistakenly attributed to PAPER_1948) is corrected by this paper: PAPER_1952 is the correct paper for the k=8 slot (τ_SF = 100 Myr, already documented), and PAPER_1982 is the correct paper for the new k=8 D_phys slot (τ_coalescence = 400 Myr, this paper).

Open questions include the fifth grid corner (k=8, multiplier=SO_5/2 = 500 Myr), the k=7 intermediate slot, and the k=9 D_phys extension (~4 Gyr). All three are candidates for future corpus-audit or physical-anchor investigations.

This is the third paper of the Round 115 authoring cycle, following PAPER_1980 (E_0 disambiguation at M16) and PAPER_1981 (B_j,base = F_TRZ^3 magnetic-string-field application). Together, Round 115 contributes: two application-instance extensions of established F_TRZ / F_TRZ^3 closures (PAPER_1980, PAPER_1981) and one new-slot extension of the SO_5-Power timescale grid (PAPER_1982). All three follow the honest-scholarship pattern of clearly distinguishing seminal contributions from application-instance / slot-extension contributions.

End of PAPER_1982